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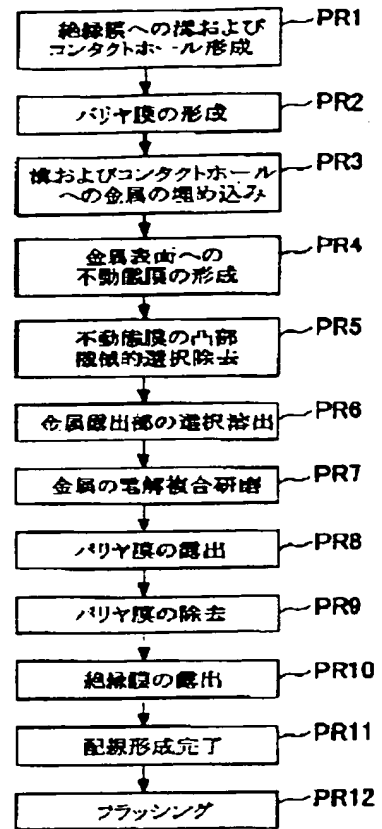
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TITLE : MANUFACTURE OF
SEMICONDUCTOR DEVICE, AND
METHOD AND DEVICE FOR
POLISHING



ABSTRACT : PROBLEM TO BE SOLVED: To provide a polishing method, a polishing device, and a manufacturing method for a semiconductor device, where occurrence of dishing or erosion is suppressed in a planarizing process for polishing a metal film to constitute wiring of a semiconductor device having a multilayer interconnection structure.

SOLUTION: A process (PR4) for forming a passive state film on the surface of a metal film which prevents electrolytic reaction of the metal, process (PR5) where a protruding passive state film present on the surface of metal film which is generated by filling a wiring channel is selectively removed by mechanical polishing so that the protruding metal film is exposed on the surface, a process (PR6) where the exposed protruding part of the metal film is removed by electrolytic polishing, so that the rough surface of the metal film generated by filling of filling of the wiring channel is planarized, and a process (PR7) where a metal film present on the insulating film of the metal film whose surface is planarized is removed by electrolytic composite polishing, where electrolytic polishing and mechanical polishing are composed to form wiring are provided.

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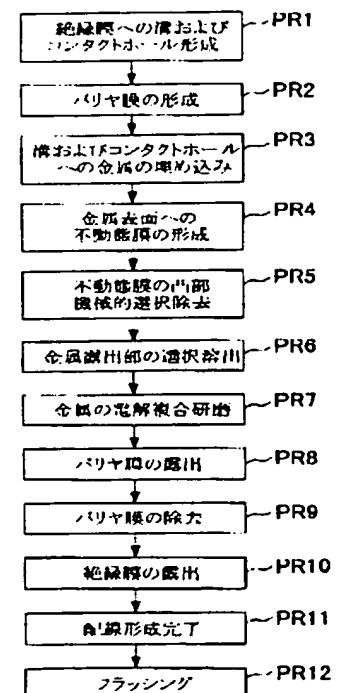
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(54) 【発明の名称】 半導体装置の製造方法、研磨装置および研磨方法

(55) 【要約】

【課題】 多層配線構造を有する半導体装置の配線を構成するための金属膜の研磨による平坦化工程において、デマージング、エッジエロージョンの発生を抑制可能な、研磨方法、研磨装置および半導体装置の製造方法を提供する。

【解決手段】 金属膜の表面に当該金属の電解反応を妨げる作用を發揮する不動態膜を形成する工程 (PR1) と、配線用溝の埋め込みによって生じた金属膜の表面に存在する凸部上の不動態膜を機械研磨によって選択的に除去し、金属膜の凸部を表面に露出させる工程 (PR5) と、露出した金属膜の凸部を電解研磨によって除去し、配線用溝の埋め込みによって生じた金属膜の表面の凹凸を平坦化する工程 (PR6) と、表面が平坦化された金属膜の絶縁膜上に存在する金属膜を電解研磨と機械研磨とを複合させた電解複合研磨によって除去し、前記配線を形成する工程 (PR7) を有する。



【特許請求の範囲】

【請求項1】基板上に形成された絶縁膜に配線を形成するための配線用溝を形成する工程と、

前記配線用溝を埋め込むように、前記絶縁膜上に金属膜を堆積させる工程と、

前記絶縁膜上に堆積した金属膜の表面に当該金属膜の電解反応を妨げる作用を充てる不動態膜を形成する工程と、

前記金属膜に形成された不動態膜のうち、前記配線用溝の埋め込みによって生じた前記金属膜の表面に存在する凸部上の不動態膜を機械研磨によって選択的に除去し、当該金属の凸部を表面に露出させる工程と、

前記露出した金属膜の凸部を電解研磨によって除去し、前記配線用溝の埋め込みによって生じた前記金属膜の表面の凹凸を平坦化する工程とを有する半導体装置の製造方法

【請求項2】前記表面が平坦化された金属膜の前記絶縁膜上に存在する余分な金属膜を電解研磨と機械研磨とを組合せた電解複合研磨によって除去し、前記配線を形成する工程をさらに有する請求項1に記載の半導体装置の製造方法

【請求項3】前記電解複合研磨は、電解研磨と化学機械研磨とを組合せる請求項2に記載の半導体装置の製造方法

【請求項4】前記配線用溝を形成した後に、前記絶縁膜上および前記溝内を覆うように前記金属膜の前記絶縁膜への拡散を防ぐための導電性材料からなるバリや膜を形成し、前記露出した金属膜の凸部を平坦化した後に、前記絶縁膜上に存在する余分な金属膜を前記電解複合研磨によって前記バリや膜が表面に露出するまで除去する工程と、

前記絶縁膜上に存在する余分なバリや膜を前記絶縁膜が表面に露出するまで前記電解複合研磨によって除去する工程とを有する請求項2に記載の半導体装置の製造方法

【請求項5】導電性を有する研磨工具の研磨面と前記不動態膜との間に電解液を介在させ、前記金属膜およびバリや膜を陽極とし前記研磨工具を陰極として、前記金属膜およびバリや膜と前記研磨工具との間に電圧を印加し、

前記研磨工具を前記不動態膜の表面に相対的に移動させて、前記金属膜の凸部に形成された不動態膜を選択的に除去し、

前記選択的に除去された不動態膜から露出した前記金属膜の凸部を前記電解液の電解作用によって溶出させる請求項1に記載の半導体装置の製造方法

【請求項6】前記研磨工具との間で電圧が印加された電極部材を前記金属膜およびバリや膜に接触または接近させて前記金属膜および前記バリや膜に通電し、

前記電極部材から前記前記金属膜および前記バリや膜を

經由して前記研磨工具に流れる電流をモニタリングし、当該電流値の大きさに基づいて前記金属膜およびバリや膜の研磨の進行を管理する請求項5に記載の半導体装置の製造方法

【請求項7】前記研磨工具との間で電圧が印加された電極部材を前記金属膜およびバリや膜に接触または接近させて前記金属膜および前記バリや膜に通電し、

前記電極部材と前記研磨工具との間に発生する電気抵抗の大きさをモニタリングし、当該電気抵抗値に基づいて前記金属膜およびバリや膜の研磨の進行を管理する請求項5に記載の半導体装置の製造方法

【請求項8】前記研磨工具の研磨面と前記不動態膜との間に研磨砥粒を含む化学研磨剤を介在させて前記不動態膜を選択的に除去する請求項5に記載の半導体装置の製造方法

【請求項9】前記金属膜と前記バリや膜とを構成する各材料に対してそれぞれ研磨レートの高い異なる化学研磨剤を用いて前記余分な金属膜とバリや膜とをそれぞれ除去する請求項5に記載の半導体装置の製造方法

【請求項10】前記余分なバリや膜を除去する工程では、前記バリや膜と前記研磨工具との間に印加する電圧を、前記余分な金属膜を除去する工程での前記金属膜と前記研磨工具との間に印加する電圧よりも低くする請求項5に記載の半導体装置の製造方法

【請求項11】前記配線用溝を形成する工程は、前記配線用溝の形成とともに、前記絶縁膜の下層に形成された不純物拡散層または配線と当該絶縁膜上に形成される配線とを接続するためのコンタクトホールを形成する工程を有し、

前記配線用溝に金属を埋め込む工程は、前記配線用溝とともに前記コンタクトホールに金属を埋め込む請求項2に記載の半導体装置の製造方法

【請求項12】前記配線の形成材料には、銅を使用し、前記配線用溝およびコンタクトホールには電気メッキ法を用いて銅を埋め込む請求項11に記載の半導体装置の製造方法

【請求項13】前記バリや膜の形成材料には、Ta、Ti、Ta-NおよびTi-Nのいずれかをを用いる請求項4に記載の半導体装置の製造方法

【請求項14】前記不動態膜は、前記金属膜の表面を酸化させた酸化膜からなる請求項1に記載の半導体装置の製造方法

【請求項15】前記金属膜の表面に酸化剤を供給して前記酸化膜を形成する請求項14に記載の半導体装置の製造方法

【請求項16】前記不動態膜は、前記金属膜を構成する金属の電解反応を妨げる作用を充てる材料からなる膜を前記金属膜の表面上に形成する請求項1に記載の半導体装置の製造方法

【請求項17】前記不動態膜は、前記金属膜の表面に、

は、水膜、油膜、酸化防止膜、界面活性剤からなる膜、キレート剤からなる膜、および、シランカップリング剤からなる膜のいずれかを形成する請求項16に記載の半導体装置の製造方法

【請求項18】前記不動態膜は、前記金属膜よりも、電気的抵抗が高く、かつ、機械的強度が低い請求項1に記載の半導体装置の製造方法

【請求項19】研磨面を有し、導電性を有する研磨工具と、

前記研磨工具を所定の回転軸を中心に回転させ、かつ、保持する研磨工具回転保持手段と、

被研磨対象物を保持し、所定の回転軸を中心に回転させる回転保持手段と、

前記研磨工具を前記被研磨対象物に対向する方向の目標位置に移動位置決めする移動位置決め手段と、

前記被研磨対象物の被研磨面と前記研磨工具の研磨面とを所定の平面に沿って相対移動させる相対移動手段と、

前記被研磨対象物の被研磨面上に電解液を供給する電解液供給手段と、

前記被研磨対象物の被研磨面を陽極とし前記研磨工具を陰極として、前記被研磨面から前記電解液を通じて前記研磨工具に流れる電解電流を供給する電解電流供給手段とを有する研磨装置

【請求項20】前記被研磨対象物の被研磨面に研磨砥粒を含む化学研磨剤を供給する研磨剤供給手段をさらに有する請求項19に記載の研磨装置

【請求項21】前記電解電流供給手段は、前記被研磨対象物の被研磨面に接触可能または接近可能に配置され、前記被研磨対象物の被研磨面を陽極として当該被研磨面に通電する通電手段と、

前記通電手段と前記研磨工具との間に所定電位を印加する直流電源とを備える請求項1に記載の研磨装置

【請求項22】前記直流電源は、所定期期のパルス状の電圧を出力する請求項21に記載の研磨装置

【請求項23】前記研磨工具は、ホイール状の導電性部材からなり、当該部材の環状の一端面が研磨面を構成しており、

前記通電手段は、前記研磨工具の内側に当該研磨工具と離隔して設けられ、前記回転保持手段によって保持され、前記研磨工具とともに回転する導電性の電極板を備える請求項21に記載の研磨装置

【請求項24】前記電極板は、前記被研磨対象物の被研磨面に対向する側に当該被研磨面をスクラブする面を有するスクラブ部材を備える請求項23に記載の研磨装置

【請求項25】前記スクラブ部材は、前記電解液および研磨砥粒を含む化学研磨剤を吸収し、かつ通過させることができる材料から形成されており、前記電極板側から供給される電解液および、または化学研磨剤を被研磨対象物の被研磨面に供給する請求項24に記載の研磨装

置

【請求項26】前記研磨工具は、前記回転保持手段に連結された導電性部材によって保持されており、前記回転する導電性部材に接触する通電ブラシを通じて通電される請求項21に記載の研磨装置

【請求項27】前記電極部材は、前記被研磨対象物の被研磨面に形成された被電解金属に対して異なる金属からなる請求項23に記載の研磨装置

【請求項28】前記被研磨対象物の被研磨面から前記研磨工具に流れる電解電流の値を検出する電流検出手段をさらに備える請求項19に記載の研磨装置

【請求項29】前記被研磨対象物の被研磨面を経由した前記電極部材と前記研磨工具との間の電気抵抗を検出する抵抗値検出手段を備える請求項23に記載の研磨装置

【請求項30】前記電流検出手段の検出信号に基づいて、前記電解電流の値が一定となるように前記研磨工具と前記被研磨対象物との対向方向の位置を制御する制御手段をさらに有する請求項29に記載の研磨装置

【請求項31】被研磨対象物の被研磨面の全面に回転しながら接触する研磨面を有する研磨工具を備え、前記被研磨対象物を前記研磨面に回転させながら接触させて平坦化研磨する研磨装置であって、

前記研磨面上に電解液を供給する電解液供給手段を有し、

前記研磨面に前記被研磨対象物の被研磨面に通電可能な陽極電極および陰極電極を備え、前記電解液による電解研磨と前記研磨面による機械研磨とを複合した電解複合研磨によって前記被研磨対象物の被研磨面を平坦化研磨する研磨装置

【請求項32】前記研磨面に研磨砥粒を含む化学研磨剤を供給する研磨剤供給手段をさらに有し、

前記電解液による電解研磨と前記研磨面および前記研磨剤による化学機械研磨とを複合した電解複合研磨によって前記被研磨対象物の被研磨面を平坦化研磨する請求項31に記載の研磨装置

【請求項33】導電性の研磨工具の研磨面と金属膜が少なくとも表面または内層に形成された被研磨対象物の表面とを電解液を介在させて押し付け、

前記研磨工具を陰極とし前記被研磨対象物の表面を陽極として、前記被研磨対象物の表面から前記研磨工具に前記電解液を通じて流れる電解電流を供給し、

前記研磨工具と前記被研磨対象物とを共に回転させながら所定の平面に沿って相対移動させ、

前記電解液による電解研磨および前記研磨面による機械研磨を複合した電解複合研磨によって前記被研磨対象物に形成された金属膜を平坦化する研磨方法

【請求項34】前記研磨面と前記被研磨対象物の表面との間に前記電解液とともに研磨砥粒を含む化学研磨剤を介在させ、前記電解液による電解研磨と前記研磨面およ

び前記研磨剤による化学機械研磨とを複合した電解複合研磨によって前記被研磨対象物に形成された金属膜を平坦化する請求項33に記載の研磨方法

【請求項35】前記被研磨対象物には、異なる材料からなる複数の膜が積層されており、

前記各膜の材料の電気的特性の違いによって変化する前記電解液を通じて前記被研磨対象物の表面から前記研磨工具に流れる電解電流をモニタリングし、当該電解電流の大きさに基づいて研磨の進行を管理する請求項33に記載の研磨方法

【請求項36】前記研磨工具と前記被研磨対象物の表面との間に、所定の周期のパルス状の電圧を印加して前記電解電流を供給する請求項33に記載の研磨方法

【請求項37】電極部材を前記電解液が供給された前記被研磨対象物の表面に接近または当接させ、前記被研磨対象物の表面へ通電する請求項33に記載の研磨方法

【請求項38】前記電極部材を前記研磨工具とともに回転させ、かつ、前記被研磨対象物に対して相対移動させることで前記被研磨対象物に形成された金属膜に通電する請求項37に記載の研磨方法

【請求項39】前記被研磨対象物の表面を經由した前記電極部材と前記研磨工具との間の電気抵抗の大きさに基づいて、前記被研磨対象物の研磨の進行を管理する請求項37に記載の研磨方法

【請求項40】前記研磨剤に含まれる研磨砥粒を正に帯電させる請求項33に記載の研磨方法

【請求項41】被研磨対象物に形成された金属膜の表面に当該金属膜の電解反応を妨げる作用を發揮する不動態膜を形成する工程と、

研磨工具の研磨面と前記金属膜との間に電解液を介在させて当該研磨面と金属膜とを押し付け、かつ、前記研磨工具と前記金属膜と間に所定の電圧を印加する工程と、

前記研磨工具の研磨面と前記被研磨対象物の金属膜とを所定の平面に沿って相対移動させ、前記金属膜のうち前記研磨工具の研磨面に対して突出した凸部上の不動態膜を前記研磨工具の機械研磨によって選択的に除去する工程と、

前記不動態膜が除去されて表面に露出した金属膜の凸部を前記電解液による電解研磨作用によって除去して前記金属膜を平坦化する工程とを有する研磨方法

【請求項42】前記研磨面と前記金属膜との間に前記電解液とともに研磨砥粒を含む化学研磨剤を介在させ、前記研磨面および前記研磨砥粒による化学機械研磨によって前記不動態膜を選択的に除去する請求項41に記載の研磨方法

【請求項43】前記不動態膜は、前記金属膜の表面を酸化させた酸化膜からなる請求項41に記載の研磨方法

【請求項44】前記不動態膜は、前記金属膜を構成する金属の電解反応を妨げる作用を發揮する材料からなる膜

を前記金属膜の表面上に形成する請求項41に記載の研磨方法

【請求項45】前記不動態膜は、前記金属膜よりも、電気的抵抗が高く、かつ、機械的強度が低い請求項41に記載の研磨方法

【請求項46】電極部材を前記金属膜の表面に接近または当接させ、前記金属膜へ通電する請求項41に記載の研磨方法

【請求項47】前記電極部材と前記研磨工具との間の電気抵抗の大きさに基づいて研磨の進行を管理する請求項46に記載の研磨方法

【請求項48】前記研磨剤に含まれる研磨砥粒を正に帯電させる請求項42に記載の研磨方法

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、たとえば、半導体装置の多層配線構造に伴う凹凸面を平坦化する研磨装置および研磨方法と多層配線構造をもつ半導体装置の製造方法に関する

【0002】

【従来の技術】半導体装置の高集積化、小型化に伴い、配線の微細化、配線ピッチの縮小化、配線の多層化が進んでおり、半導体装置の製造プロセスにおける多層配線技術の重要性が増大している。一方、従来、多層配線構造の半導体装置の配線材料としてアルミニウム（Al）が多用されてきたが、最近の0.25 μ mルール以下のデザインルールにおいて、信号の伝搬遅延を抑制するために、配線材料をアルミニウム（Al）から銅（Cu）に代えた配線プロセスの開発が盛んに行われている。Cuを配線に使用すると、低抵抗と高エレクトロマイグレーション耐性を両立できるというメリットがある。このCuを配線に使用したプロセスでは、たとえば、あらかじめ層間絶縁膜に形成した溝状の配線パターンに金属を埋め込み、CMP（Chemical Mechanical Polishing：化学機械研磨）法によって余分な金属膜を除去して配線を形成する、ダマシン（damascene）法とよばれる配線プロセスが有力となっている。このダマシン法は、配線のエッチングが不要となり、さらに上の層間絶縁膜も自ずと平坦なものとなるので、工程を簡略化できるという特徴を有する。さらに、層間絶縁膜に配線だけでなく、コンタクトホールも溝として開け、配線とコンタクトホールを同時に金属で埋め込むデュアルダマシン（dual damascene）法では、さらに大幅な配線工程の削減が可能となる

【0003】ここで、上記のデュアルダマシン法による配線形成プロセスの一例について図32～図37を参照して説明する。なお、配線材料としてCuを用いた場合について説明する。まず、図32に示すように、たとえば、図示しない不純物拡散領域が適宜形成されているシリコン等の半導体からなる基板301上に、たとえば、

シリコン酸化膜からなる層間絶縁膜302を、たとえば、減圧CVD(Chemical Vapour Deposition)法により形成する。次いで、図33に示すように、基板301の不純物拡散領域に通じるコンタクトホール303および基板301の不純物拡散領域と電気的に接続される所定パターンの配線が形成される溝304を公知のフォトリソグラフィ技術およびエッチング技術を用いて形成する。次いで、図34に示すように、バリア膜305を層間絶縁膜302の表面およびコンタクトホール303、溝304内に形成する。このバリア膜305は、たとえば、Ta、Ti、Ta₂N、Ti₂N等の材料を公知のスパッタ法により形成する。バリア膜305は、配線を構成する材料が層間絶縁膜302中に拡散するのを防止するために設けられる。特に、配線材料がCuで層間絶縁膜302がシリコン酸化膜のような場合には、Cuはシリコン酸化膜への拡散係数が大きく、酸化されやすいため、これを防止する。

【0004】次いで、図35に示すように、バリア膜305上に、シードCu膜306を公知のスパッタ法により所定の膜厚で形成し、次いで、図36に示すように、コンタクトホール303および溝304をCuで埋め込むように、Cu膜307を形成する。Cu膜307は、たとえば、メッキ法、CVD法、スパッタ法等によって形成する。次いで、図37に示すように、層間絶縁膜302上の余分なCu膜307およびバリア膜305をCMP法によって除去し、平坦化する。これによって、配線308およびコンタクト309とが形成される。上記したプロセスを配線308上で繰り返し行うことにより、多層配線を形成することができる。

【0005】

【発明が解決しようとする課題】ところで、上記したデュアルダマシニング法を用いた多層配線形成プロセスでは、余分なCu膜307およびバリア膜305をCMP法によって除去する工程において、層間絶縁膜302とCu膜307およびバリア膜305との除去性能が異なることから、配線308にディッシング、エロージョン(シンニング)、リセス等が発生しやすいという不利益が存在した。ディッシングは、図38に示すように、たとえば、0.18 μ mルールでのデザインルールにおいて、たとえば、100 μ m程度のような幅の広い配線308が存在した場合に、当該配線の中央部が過剰に除去され、こんでしまう現象であり、このディッシングが発生すると配線308の断面積が不足するため、配線抵抗値不良等の原因となる。このディッシングは、配線材料に比較的軟質の銅やアルミニウムを用いた場合に発生しやすい。エロージョンは、図39に示すように、たとえば、3000 μ mの範囲に1.0 μ mの幅の配線が50パーセントの密度で形成されているようなパターン密度の高い部分が過剰に除去されてしまう現象であり、エロージョンが発生すると配線の断面積が不足するため、配線抵抗値不良等の原因となる。リセスは、図40に示すように、層間絶縁膜302と配線308との境界で配線308が低くなり段差ができってしまう現象であり、この場合にも配線の断面積が不足するため、配線抵抗値不良等の原因となる。さらに、余分なCu膜307およびバリア膜305をCMP法によって除去する工程では、Cu膜307およびバリア膜305を効率的に除去する必要があり、単位時間当たりの除去量である研磨レートは、たとえば、500nm/min以上となるように要求されている。この研磨レートを稼ぐためにはウェーハに対する加工圧力を大きくする必要があり、加工圧力を大きくすると、図41に示すように、配線表面にスクラッチやケミカルダメージ等が発生しやすくなり、特に、軟質のCuやアルミニウムでは発生しやすい。このため、配線のオープン、ショート、配線抵抗値不良等の不具合の原因となり、また、加工圧力を大きくすると、上記のディッシング、エロージョン、リセスの発生量も大きくなるという不利益が存在した。

【0006】本発明は、上記した問題に鑑みてなされたものであって、たとえば、多層配線構造を有する半導体装置の配線等の金属膜を研磨によって平坦化する際に、初期凹凸を容易に平坦化でき、かつ余分な金属膜の除去効率に優れ、ディッシング、エロージョン等の金属膜の過剰な除去の発生を抑制可能な研磨装置および研磨方法、半導体装置の製造方法を提供する。

【0007】

【課題を解決するための手段】本発明の研磨装置は、研磨面を有し、帯電性を有する研磨工具と、前記研磨工具を所定の回転軸を中心として回転させ、かつ、保持する研磨工具回転保持手段と、被研磨対象物を保持し、所定の回転軸を中心として回転させる回転保持手段と、前記研磨工具を前記被研磨対象物に対向する方向の目標位置に移動位置決めする移動位置決め手段と、前記被研磨対象物の被研磨面と前記研磨工具の研磨面とを所定の平面に沿って相対移動させる相対移動手段と、前記被研磨対象物の被研磨面上に電解液を供給する電解液供給手段と、前記被研磨対象物の被研磨面を陽極とし前記研磨工具を陰極として、前記被研磨面から前記電解液を通じて前記研磨工具に流れる電解電流を供給する電解電流供給手段とを有する。

【0008】また、本発明の研磨装置は、被研磨対象物の被研磨面の全面に回転しながら接触する研磨面を有する研磨工具を備え、前記被研磨対象物を前記研磨面に回転させながら接触させて平坦化研磨する研磨装置であって、前記研磨面上に電解液を供給する電解液供給手段を有し、前記研磨面に前記被研磨対象物の被研磨面に通電可能な陽極電極および陰極電極を備え、前記電解液による電解研磨と前記研磨面による機械研磨とを複合した電解複合研磨によって前記被研磨対象物の被研磨面を平坦化研磨する。

【0009】本発明の研磨方法は、導電性の研磨工具の研磨面と金属膜が少なくとも表面または内層に形成された被研磨対象物の表面とを電解液を介在させて押し付け、前記研磨工具を陰極とし前記被研磨対象物の表面を陽極として、前記被研磨対象物の表面から前記研磨工具に前記電解液を通じて流れる電解電流を供給し、前記研磨工具と前記被研磨対象物とを共に回転させながら所定の平面に沿って相対移動させ、前記電解液による電解研磨および前記研磨面による機械研磨を複合した電解複合研磨によって前記被研磨対象物に形成された金属膜を平坦化する。

【0010】また、本発明の研磨方法は、被研磨対象物に形成された金属膜の表面に当該金属膜の電解反応を妨げる作用を發揮する不動態膜を形成する工程と、導電性の研磨工具の研磨面と前記金属膜との間に電解液を介在させて当該研磨面と金属膜とを押し付け、かつ、前記研磨工具と前記金属膜と間に所定の電圧を印加する工程と、前記研磨工具の研磨面と前記被研磨対象物の金属膜とを所定の平面に沿って相対移動させ、前記金属膜のうち前記研磨工具の研磨面に対して突出した凸部上の不動態膜を前記研磨工具の機械研磨によって選択的に除去する工程と、前記不動態膜が除去されて表面に露出した金属膜の凸部を前記電解液による電解研磨作用によって除去して前記金属膜を平坦化する工程とを有する。

【0011】本発明の半導体装置の製造方法は、基板上に形成された絶縁膜に配線を形成するための配線用溝を形成する工程と、前記配線用溝を埋め込むように、前記絶縁膜上に金属膜を堆積させる工程と、前記絶縁膜上に堆積した金属膜の表面に当該金属膜の電解反応を妨げる作用を發揮する不動態膜を形成する工程と、前記金属膜に形成された不動態膜のうち、前記配線用溝の埋め込みによって生じた前記金属膜の表面に存在する凸部上の不動膜を機械研磨によって選択的に除去し、当該金属の凸部を表面に露出させる工程と、前記露出した金属膜の凸部を電解研磨によって除去し、前記配線用溝の埋め込みによって生じた前記金属膜の表面の凹凸を平坦化する工程とを有する。

【0012】また、本発明の半導体装置の製造方法は、前記表面が平坦化された金属膜の前記絶縁膜上に存在する余分な金属膜を電解研磨と機械研磨とを複合させた電解複合研磨によって除去し、前記配線を形成する工程をさらに有する。

【0013】本発明の半導体装置の製造方法では、表面に凹凸がある金属膜に不動態膜を形成し、不動態膜を機械的に除去することで、金属膜の凸部が表面に露出する。この金属膜の凸部は残った不動態膜をマスクとして電解液による電解作用によって選択的に溶出する。この結果、金属膜の初期凹凸が平坦化される。また、初期凹凸が平坦化された金属膜は、電解複合研磨によって高効率に除去され、たとえば、配線を形成する際に絶縁膜上

に存在する余分な金属膜は高効率に除去される。余分な金属膜が除去されて絶縁膜が露出すると、自動的にその部分の電解作用が停止し、絶縁膜に形成された配線用溝に埋め込まれた金属膜が過剰に除去されない。

【0014】

【発明の実施の形態】以下、本発明の実施の形態について図面を参照して説明する。

研磨装置の構成

図1は、本発明の一実施形態に係る研磨装置の構成を示す図である。図2は図1に示す研磨装置の加工ヘッド部の要部拡大図である。図1に示す研磨装置1は、加工ヘッド部2と、電解電源61と、研磨装置1全体を制御する機能を有するコントローラ5と、スラリー供給装置71と、電解液供給装置81とを備えている。なお、図示しないが、研磨装置1は、クリーンルーム内に設置され、当該クリーンルーム内には被研磨対象物としてのウェーハを収容したウェーハカセットを搬出入する搬出入ポートが設けられている。さらに、この搬出入ポートを通じてクリーンルーム内に搬入されたウェーハカセットと研磨装置1との間でウェーハの受け渡しを行うウェーハ搬送ロボットが搬出入ポートと研磨装置1との間に設置される。

【0015】加工ヘッド部2は、研磨工具3を保持し回転させ、研磨工具3を保持する研磨工具保持部11と、研磨工具保持部11をZ軸方向の目標位置に位置決めするZ軸位置決め機構部31と、被研磨対象物としてのウェーハWを保持し回転させX軸方向に移動するX軸移動機構部41とを備える。なお、研磨工具保持部11が本発明の研磨工具回転保持手段の一具体例に対応しており、X軸移動機構部41が本発明の回転保持手段および相対移動手段の一具体例に対応しており、Z軸位置決め機構部31は本発明の移動位置決め手段の一具体例に対応している。

【0016】Z軸位置決め機構部31は、図示しないコラムに固定されたZ軸サーボモータ18と、保持装置12および主軸モータ13に連結され、Z軸サーボモータ18に接続されたボールネジ軸18aに結合するネジ部が形成されたZ軸スライダ16と、Z軸スライダ16をZ軸方向に移動自在に保持する図示しないコラムに設置されたガイドレール17とを有する。

【0017】Z軸サーボモータ18は、Z軸サーボモータ18に接続されたZ軸ドライバ52から駆動電流が供給されて回転駆動される。ボールネジ軸18aは、Z軸方向に沿って設けられ、一端がZ軸サーボモータ18に接続され、他端は、上記の図示しないコラムに設けられた保持部材によって回転自在に保持されている。これにより、Z軸位置決め機構部31は、Z軸サーボモータ18の駆動によって、研磨工具保持部11に保持された研磨工具3をZ軸方向の任意の位置に移動位置決めする。Z軸位置決め機構部31の位置決め精度は、たとえ

ば、分解能0.1 μ m程度としている

【0018】N軸移動機構41は、ウェハWをチャッキングするウェハテーブル42と、ウェハテーブル42を回転自在に保持する保持装置45と、ウェハテーブル42を回転させる駆動力を供給する駆動モータ44と、駆動モータ44と保持装置45の回転軸とを連結するベルト46と、保持装置45に設けられた加工パン17と、駆動モータ44および保持装置45が設置されたN軸スライダ48と、図示しない架台に基台されたN軸サーボモータ19と、N軸サーボモータ19に接続されたボールネジ軸49aと、N軸スライダ48に連結されたボールネジ軸49aに結合するネジ部が形成された可動部材49bとを有する

【0019】ウェハテーブル42は、たとえば、真空吸着手段によってウェハWを吸着する。加工パン47は、使用済の電解液や、スラリー等の液体を回収するために設けられている。駆動モータ14は、テーブルドライブ51から駆動電流が供給されることによって駆動され、この駆動電流を制御することでウェハテーブル42を所定の回転数で回転させることができる。N軸サーボモータ49は、N軸サーボモータ49に接続されたN軸ドライブ51から供給される駆動電流によって回転駆動し、N軸スライダ18がボールネジ軸19aおよび可動部材49bを介してN軸方向に駆動する。このとき、N軸サーボモータ49に供給する駆動電流を制御することによって、ウェハテーブル42のN軸方向の速度制御が可能となる

【0020】図2は、研磨工具保持部11の内部構造の一例を示す図である。研磨工具保持部11は、研磨工具3と、研磨工具3を保持するフランジ部材4と、フランジ部材4を回転自在に保持する保持装置12と、保持装置12に保持された主軸12aと接続され当該主軸12aを回転させる主軸モータ13と、主軸モータ13上に設けられたシリンダ装置14とを備える

【0021】主軸モータ13は、たとえば、ダイレクトドライブモータからなり、このダイレクトドライブモータの図示しないロータは、保持装置12に保持された主軸12aに連結されている。また、主軸モータ13は中心部にシリンダ装置14のピストンロッド14bが挿入される貫通孔を有している。主軸モータ13は、主軸ドライブ51から供給される駆動電流によって駆動される

【0022】保持装置12は、たとえば、エアベアリングを備えており、このエアベアリングで主軸12aを回転自在に保持している。保持装置12の主軸12aも中心部にシリンダ装置14のピストンロッド14bが挿入される貫通孔を有している

【0023】フランジ部材4は、金属材料から形成されており、保持装置12の主軸12aに連結され、底部に開口部4aを備え、下端面4bに研磨工具3が固着され

ている。フランジ部材4の上端面4c側は保持装置12に保持された主軸12aに連結されており、主軸12aの回転によってフランジ部材4も回転する。フランジ部材4の上端面4cは、主軸モータ13および保持装置12の側面に設けられた導電性の通電部材28に固定された通電ブラシ27と接触しており、通電ブラシ27とフランジ部材4とは電気的に接続されている

【0024】シリンダ装置14は、主軸モータ13のケース上に固定されており、ピストン14aを内蔵しており、ピストン14aは、たとえば、シリンダ装置14内に供給される空気圧によって矢印A1およびA2のいずれかの向きに駆動される。このピストン14aには、ピストンロッド14bが連結されており、ピストンロッド14bは、主軸モータ13および保持装置12の中心を通って、フランジ部材4の開口部4aから突き出ている。ピストンロッド14bの先端には、押圧部材21が連結されており、この押圧部材21はピストンロッド14bに対して所定の範囲で姿勢変更が可能な連結機構によって連結されている。押圧部材21は、対向する位置に配置された絶縁板22の開口22aの周縁部に当接可能となっており、ピストンロッド14bの矢印A2方向への駆動によって絶縁板22を押圧する

【0025】シリンダ装置14のピストンロッド14bの中心部には、貫通孔が形成されており、貫通孔内に通電軸20が挿入され、ピストンロッド14bに対して固定されている。通電軸20は、導電性材料から形成されており、上端側はシリンダ装置14のピストン14aを貫通してシリンダ装置14上に設けられたロータリジョイント15まで伸びており、下端側は、ピストンロッド14bおよび押圧部材21を貫通して電極板23まで伸びており、電極板23に接続されている

【0026】通電軸20は、中心部に貫通孔が形成されており、この貫通孔が化学研磨剤（スラリー）および電解液をウェハW上に供給する供給ノズルとなっている。また、通電軸20は、ロータリジョイント15と、電極板23とを電気的に接続する役割を果たしている

【0027】通電軸20の上端部に接続されたロータリジョイント15は、電解電極61のプラス極と電気的に接続されており、このロータリジョイント15は通電軸20が回転しても通電軸20への通電を維持する。すなわち、通電軸20は回転してもロータリジョイント15によって電解電極61からプラスの電位が印加される

【0028】通電軸20の下端部に接続された電極板23は、金属材料からなり、特に、ウェハWに形成される金属膜より貴なる金属で形成されている。電極板23は、上面側が絶縁板22に保持されており、電極板23の外周部は絶縁板22に嵌合しており、下面側にはスクラブ部材24が貼着されている

【0029】ここで、図3(a)は電極板23の構造の一例を示す下面図であり、図3(b)は電極板23と、

通電軸20、スクラブ部材24および絶縁部材4との位置関係を示す断面図である。図3(a)に示すように、電極板23の中央部には円形の開口部23aが設けられており、この開口部23aを中心に電極板23の半径方向に放射状に伸びる複数の溝部23bが形成されている。また、図3(b)に示すように、電極板23の開口部23aには、通電軸20の下端部が嵌合固着されている。このような構成とすることで、通電軸20の中心部に形成された供給ノズル20aを通じて供給されるスラリーおよび電解液が溝部23bを通じてスクラブ部材24の全面に拡散するようになっている。すなわち、電極板23と、通電軸20、スクラブ部材24および絶縁部材4が回転しながら、スラリーおよび電解液が通電軸20の中心部に形成された供給ノズル20aを通じてスクラブ部材24の上側面に供給されると、スクラブ部材24の上側面全体にスラリーおよび電解液が広がる。なお、スクラブ部材24および通電軸20の供給ノズル20aが本発明の研磨剤供給手段および電解液供給手段の一具体例に対応している。また、電極板23、通電軸20およびロータリジョイント15が本発明の通電手段の一具体例に対応している。

【0030】電極板23の下面に貼着されたスクラブ部材21は、電解液およびスラリーを吸収し、これらを上側面から下側面に通過させることができる材料から形成されている。また、このスクラブ部材24は、ウェーハWに対向する面がウェーハWに接触してウェーハWをスクラブする面となっており、ウェーハW表面にスクラッチ等を発生させないように、たとえば、柔らかいブラシ状の材料、スポンジ状の材料、多孔質状の材料等から形成される。たとえば、ウレタン樹脂、メラミン樹脂、エポキシ樹脂、ポリビニルアセタール(PVA)などの樹脂からなる多孔質体が挙げられる。

【0031】絶縁板22は、たとえば、セラミクス等の絶縁材料から形成されており、この絶縁板22は複数の棒状の連結部材26によって保持装置12の主軸12aに連結されている。連結部材26は、絶縁板22の中心軸から所定の半径位置に等間隔に配置されており、保持装置12の主軸12aに対して移動自在に保持されている。このため、絶縁板22は主軸12aの軸方向に移動可能である。また、絶縁板22と主軸12aの間には、各連結部材26に対応して、たとえば、コイルスプリングからなる弾性部材25で接続されている。

【0032】絶縁板22を保持装置12の主軸12aに対して移動自在にし、絶縁板22と主軸12aとを弾性部材25で連結する構成とすることにより、シリンダ装置14に高圧エアを供給してヒストンロッド14bを矢印A2の向きに下降させると、押圧部材21が弾性部材25の復元力に連動して絶縁板22を下方に押し下げ、これとともにスクラブ部材24も下降する。この状態からシリンダ装置14への高圧エアの供給を停止すると、

弾性部材25の復元力によって、絶縁板22は上昇し、これとともにスクラブ部材24も上昇する。

【0033】研磨工具3は、フランジ部材1の環状の下端面4bに固着されている。この研磨工具3は、ホイール状に形成されており、下端面に環状の研磨面3aを備えている。研磨工具3は、導電性を有しており、好ましくは、比較的軟質性の材料で形成する。たとえば、バインダマトリクス(結合剤)自体が導電性を持つカーボンや、あるいは、焼結銅、メタルコンパウンド等の導電性材料を含有するウレタン樹脂、メラミン樹脂、エポキシ樹脂、ポリビニルアセタール(PVA)などの樹脂からなる多孔質体から形成することができる。研磨工具3は、導電性を有するフランジ部材1に直接接続され、フランジ部材1に接触する通電ブラシ27から通電される。すなわち、主軸モータ13および保持装置12の側面に設けられた導電性の通電部材28は、電解電源61のマイナス極と電気的に接続され、通電部材28に設けられた通電ブラシ27はフランジ部材4の上端面4cに接触しており、これにより、研磨工具3は電解電源61と通電部材28、通電ブラシ27およびフランジ部材1を介して電気的に接続されている。

【0034】研磨工具3は、たとえば、図4に示すように、研磨面3aは中心軸に対して微小な角度で傾斜している。また、保持部材12の主軸12aもウェーハWの主面に対して研磨面3aの傾斜と同様に傾斜している。たとえば、保持部材12のZ軸スライダ16への取り付け姿勢を調整することで主軸12aの微小な傾斜をつくり出すことができる。このように、研磨工具3の中心軸がウェーハWの主面に対して微小角度で傾斜していることにより、研磨工具3の研磨面3aを所定の加工圧力でウェーハWに押し付けた際に、研磨面3aのウェーハWに対する実効的な作用領域Sが図4に示すように、研磨工具3の半径方向に伸びる直線状の領域となる。このため、ウェーハWを研磨工具3に対してX軸方向に移動させて研磨下降を行う際に、図5(a)の状態から図5(b)に移動する間、実効的な作用領域Sの面積は略一定となる。本実施形態に係る研磨装置1では、研磨工具3の研磨面3aの一部を部分的にウェーハWの表面に作用させ、実効的作用領域SをウェーハWの表面に均一に走査させてウェーハWの全面を均一に研磨する。

【0035】電解電源61は、上記したロータリジョイント15と通電ブラシ12との間に所定の電圧を印加する装置である。ロータリジョイント15と通電ブラシ12との間に電圧を印加することによって、研磨工具3とスクラブ部材24との間には電位差が発生する。電解電源61には、常に一定の電圧を出力する定電圧電源ではなく、好ましくは、電圧を一定周期でパルス状に出力する、たとえば、スイッチング・レギュレータ回路を内蔵した直流電源を使用する。具体的には、パルス状の電圧を一定周期で出力し、パルス幅を適宜変更可能な電源を

使用する。一例としては、出力電圧がDC150V、最大出力電流が2〜3A、パルス幅が1、2、5、10、20、50μsのWがれかに変更可能なものを使用し、上記のような幅が無いパルス状の電圧出力とするのは、1パルス当たりの電解溶出量を非常に小さくするためである。すなわち、ウェーハWの表面に形成された金属膜の凹凸や接触した場合などにみられる極間距離の急変による放電、気泡やパーティクルなどが介在した場合におこる電気抵抗の急変によるスパーク放電など、金属膜の突発的なクレータ状の巨大溶出を防止、あるいは、できる限り抑制する小さなものの連続にするために有効である。また、出力電流に比して出力電圧が比較的高いため、極間距離の設定にある程度のマージンを設定する事によって、すなわち、極間距離が多少変わっても出力電圧の高い方の電流値変化は小さい。

【0036】電解電源61には、本発明の電流検出手段としての電流計62を備えており、この電流計62は、電解電源61に流れる電解電流をモニタするために設けられており、モニタした電流値信号62sをコントローラ55に出力する。また、電解電源61は、本発明の抵抗値検出手段としての抵抗計63を備えており、この抵抗計63は電解電源61に流れる電流に基づいて、ウェーハWの表面を経由した研磨工具3と電極板23との間の電気抵抗をモニタリングするために設けられており、モニタリングした電気抵抗値信号63sをコントローラ55に出力する。

【0037】スラリー供給装置71は、スラリーを上記の通電軸20の供給ノズル20aに供給する。スラリーとしては、金属膜の研磨用として、たとえば、過酸化水素、硝酸銀、ヨウ素酸カリウム等をベースとした酸化力のある水溶液に酸化アルミニウム（アルミナ）、酸化セリウム、シリカ、酸化ゲルマニウム等を研磨砥粒として含有させたものを使用する。また、研磨砥粒は、分散性を良くしてコロイド状態を保持するために予め正に帯電させておく。

【0038】電解液供給装置81は、電解液E1を加工ヘッド部11に供給する。電解液E1は、溶媒とイオン的に分離した溶質とからなる溶液である。この電解液として、たとえば、硝酸塩あるいは塩化物系に還元剤を調整した水溶液を使用することができる。

【0039】コントローラ55は、研磨装置1の全体を制御する機能を有し、具体的には、主軸ドライバ51に対して制御信号51sを出力して研磨工具3の回転数を制御し、Z軸ドライバ52に対して制御信号52sを出力して研磨工具3のZ軸方向の位置決め制御を行い、テーブルドライバ53に対して制御信号53sを出力してウェーハWの回転数を制御し、X軸ドライバ54に対して制御信号54sを出力して、ウェーハWのX軸方向の速度制御を行う。また、コントローラ55は、電解液供給装置81およびスラリー供給装置71の動作を制御

し、加工ヘッド部2への電解液E1およびスラリーS1の供給動作を制御する。

【0040】また、コントローラ55は、電解電源61の出力電圧、出力パルスの周波数、出力パルスの幅等を制御可能となっている。また、コントローラ55には、電解電源61の電流計62および抵抗計63からの電流値信号62sおよび電気抵抗値信号63sが入力される。コントローラ55は、これら電流値信号62sおよび電気抵抗値信号63sに基づいて、研磨装置1の動作を制御可能となっている。具体的には、電流値信号62sから得られた電解電流が一定となるように、電流値信号62sをフィードバック信号としてZ軸サーボモータ18の制御したり、電流値信号62sまたは電気抵抗値信号63sで特定される電流値、電気抵抗値の値に基づいて、研磨加工を停止させるように研磨装置1の動作を制御する。

【0041】コントローラ55に接続されたコントロールパネル56は、オペレータが各種のデータを入力したり、たとえば、モニタリングした電流値信号62sおよび電気抵抗値信号63sを表示したりする。

【0042】次に、上記した研磨装置1による研磨動作をウェーハW表面に形成された金属膜を研磨する場合を例に説明する。なお、ウェーハWの表面には、たとえば、銅からなる金属膜が形成されている場合について説明する。まず、ウェーハテーブル45にウェーハWをチャッキングし、ウェーハテーブル45を駆動して所定の回転数でウェーハWを回転させる。また、ウェーハテーブル45をX軸方向に移動して、フランジ部41に取り付けられた研磨工具3をウェーハWの上方の所定位置に位置させ、研磨工具3を所定の回転数で回転させる。研磨工具3を回転させると、フランジ部41に連結された絶縁板22、電極板23およびスクラブ部材24も同回転駆動される。また、スクラブ部材24を押圧している押圧部材21、ピストンロッド14b、ピストン14a、通電軸20も同時に回転する。

【0043】この状態から、スラリー供給装置71および電解液供給装置81からそれぞれスラリーS1および電解液E1を通電軸20内の供給ノズル20aに供給すると、スクラブ部材24の全面からスラリーS1および電解液E1が供給される。研磨工具3をZ軸方向に下降させて研磨工具3の研磨面3aをウェーハWの表面に接触させ、所定の加工圧力で押圧させる。また、電解電源61を起動させて、通電ブラシ27を通じて研磨工具3にマイカスの電位を印加し、ロータリジョイント15を通じてスクラブ部材24にプラスの電位を印加する。

【0044】さらに、シリンダ装置14に高圧エアを供給して、図1の矢印A2の方向にピストンロッド14bを下降させ、スクラブ部材24の下面をウェーハWに接触あるいは接近する位置まで移動させる。この状態からウェーハテーブル45をX軸方向に所定の速度パターン

で移動させ、ウェーハWの全面を一様に研磨加工する。

【0045】ここで、図6は、研磨装置1において研磨工具3をZ軸方向に下降させ、ウェーハWの表面に接触させた状態を示す概略図であり、図7は図6の円C内の拡大図であり、図8は図7の円D内の拡大図である。図7に示すように、スクラブ部材24はウェーハWに形成された金属膜MTに、ウェーハW上に供給された電解液ELを介して、または、直接接触することにより陽極として通電し、研磨工具3もウェーハWに形成された金属膜MTに、ウェーハW上に供給された電解液ELを介して、または、直接接触することにより陰極として通電する。なお、図7に示すように、金属膜MTとスクラブ部材24との間には、ギャップ6bが存在している。さらに、図8に示すように、金属膜MTと研磨工具3の研磨面3aとの間にはギャップ6wが存在している。図7に示すように、絶縁板4は、研磨工具3とスクラブ部材24（電極板23）との間に介在しているが、絶縁板4の抵抗R0は非常に大きく、したがって、スクラブ部材24から絶縁板4を介して研磨工具3に流れる電流 i_1 はほぼ零であり、スクラブ部材24から絶縁板4を介して研磨工具3には電流が流れない。

【0046】このため、スクラブ部材24から研磨工具3に流れる電流は、直接電解液EL中の抵抗R1を経由して研磨工具3に流れる電流 i_1 と、電解液EL中からウェーハWの表面に形成された銅からなる金属膜MTを経由して再度電解液EL中を通過して研磨工具3に流れる電流中に流れる電流 i_2 に分岐する。金属膜MTの表面に電流 i_2 が流れると、金属膜MTを構成する銅は、電解液ELの電解作用によってイオン化し、電解液EL中に溶出する。

【0047】ここで、電解液EL中の抵抗R1は、陽極としてのスクラブ部材24と陰極としての研磨工具3との距離dに比例して極端に大きくなる。このため、極間距離dを、ギャップ6bおよびギャップ6wよりも十分に大きくしておくことで、直接電解液EL中の抵抗R1を経由して研磨工具3に流れる電流 i_1 は非常に小さくなり、電流 i_2 が大きくなって、電解電流のほとんどは金属膜MTの表面を経由することになる。このため、金属膜MTを構成する銅の電解溶出を効率的に行うことができる。また、電流 i_2 の大きさは、ギャップ6bおよびギャップ6wの大きさによって変化するため、上述したように、コントローラ5によって研磨工具3のZ軸方向の位置制御を行ってギャップ6bおよびギャップ6wの大きさを調整することにより、電流 i_2 を一定にすることができる。ギャップ6wの大きさの調整は、電流値信号62sから得られた電解電流、すなわち、電流 i_2 が一定となるように、電流値信号62sをフィードバック信号としてZ軸サーボモータ18の制御を行うことで可能である。また、研磨装置1のZ軸方向の位置決め精度は分解能0.1 μm と十分に高く、加えて、主軸12

をウェーハWの主面に対して微小角度で傾斜させていることで実行的な接触面積Sは常に一定に維持されることから、電解電流の値を一定に制御すれば、電流密度は常に一定とでき、金属膜の電解溶出量も常に一定にすることができる。

【0048】以上のように、上記構成の研磨装置1は、上述したウェーハWに形成された金属膜MTを構成する金属を電解液ELによる電解作用によって溶出除去する電解研磨機能を備えている。さらに、上記構成の研磨装置1は、この電解研磨機能に加えて、研磨工具3およびスラリーSLによる通常のCMP装置の化学機械研磨機能も備えており、ウェーハWをこれら電解研磨機能および化学機械研磨の複合作用によって研磨すること（以下、電解複合研磨という）もできる。また、上記構成の研磨装置1は、スラリーSLを用いずに研磨工具3の研磨面3aの機械的な研磨と電解研磨機能との複合作用によって研磨加工を行うこともできる。上記構成の研磨装置1は、電解研磨および化学機械研磨の複合作用によって金属膜を研磨できるため、化学機械研磨のみ、あるいは、機械研磨のみを用いた研磨装置に比べてはるかに高効率に金属膜の除去を行うことができる。金属膜に対する高い研磨レートが得られるため、研磨工具3のウェーハWに対する加工圧力を化学機械研磨のみ、あるいは機械研磨のみを用いた研磨装置に比べて低く抑えることが可能となり、ディッシング、エロージョンの発生を抑制することができる。

【0049】以下、本実施形態に係る研磨装置1の電解複合研磨機能を用いた研磨方法について、多層配線構造の半導体装置のデュアルダマシニング法による配線形成プロセスに適用した場合を例に説明する。

【0050】図9は、本発明の半導体装置の製造方法の一実施形態に係る製造プロセスを示す工程図であり、図9に示す工程図に基づいて本実施形態に係る製造プロセスを説明する。まず、図10に示すように、たとえば、図示しない不純物拡散領域が適宜形成されている、たとえば、シリコン等の半導体からなるウェーハW上に、たとえば、シリコン酸化膜(SiO_2)からなる層間絶縁膜102を、たとえば、反応源としてTEOS(tetraethoxysilicate)を用いて減圧CVD(Chemical Vapor Deposition)法により形成する。次いで、図11に示すように、ウェーハの不純物拡散領域に通じるコンタクトホール103およびウェーハWの不純物拡散領域と電気的に接続される所定パターンの配線が形成される配線用溝104を、たとえば、公知のフォトリソグラフィ技術およびエッチング技術を用いて形成する。なお、配線用溝104の深さは、たとえば、800 nm程度である。

【0051】次いで、図12に示すように、バリヤ膜105を層間絶縁膜102の表面およびコンタクトホール103、配線用溝104内に形成する。このバリヤ膜3

05は、たとえば、Ta、Ti、Ta₂N、TiN等の材料をスパッタリング装置、真空蒸着装置等を用いたPVD(Physical Vapor Deposition)法により、たとえば、15nm程度の膜厚で形成する。バリア膜305は、配線を構成する材料が層間絶縁膜102中に拡散するのを防止するため、および、層間絶縁膜102との密着性を上げるために設けられる。特に、配線材料が銅で層間絶縁膜102がシリコン酸化膜のような場合には、銅はシリコン酸化膜への拡散係数が大きく、酸化されやすいので、これを防止する。以上までのプロセスが図9に示すプロセスPR1である。

【0052】次に、図13に示すように、バリア膜105上に、配線形成材料と同じ材料、たとえば、銅からなるシード膜106を公知のスパッタ法により、たとえば、150nm程度の膜厚で形成する(プロセスPR2)。シード膜106は、銅を配線用溝およびコンタクトホール内に埋め込んだ際に、銅グレインの成長を促すために形成する。次に、図14に示すように、コンタクトホール103および配線用溝104を埋め込むように、バリア膜105上に銅からなる金属膜107を、たとえば、2000nm程度の膜厚で形成する。金属膜107は、好ましくは、電解メッキ法または無電解メッキ法によって形成するが、CVD法、スパッタ法等によって形成してもよい。なお、シード膜106は金属膜107と一体化する(プロセスPR3)。

【0053】ここで、図15は金属膜107をバリア膜105上に形成した製造プロセス途中の半導体装置の断面の拡大図である。図15に示すように、金属膜107の表面には、コンタクトホール103および配線用溝104への埋め込みのために、たとえば、600nm程度の高さの凹凸が発生している。以上のプロセスは、従来と同様のプロセスで行われるが、本発明の研磨方法では、層間絶縁膜102上に存在する余分な金属膜107およびバリア膜105の除去を化学機械研磨ではなく、上記の研磨装置1の電解液合研磨によって行う。また、本発明の研磨方法では、上記の電解液合研磨によるプロセスに先立って、図16に示すように、金属膜107の表面に不動態膜108を形成する(プロセスPR4)。この不動態膜108は、金属膜107を構成する金属(銅)の電解反応を妨げる作用を発揮する材料からなる膜である。

【0054】不動態膜108の形成方法は、たとえば、金属膜107の表面に酸化剤を塗布して酸化膜を形成する。金属膜107を構成する金属が銅の場合には、酸化銅(Cu₂O)が不動態膜108となる。また、他の方法として、金属膜107の表面に、たとえば、水膜、油膜、酸化防止膜、界面活性剤からなる膜、キレート剤からなる膜、および、シランカップリング剤からなる膜のいずれかを形成して不動態膜108とすることも可能である。不動態膜108の種類は特に限定されないが、

電気抵抗が金属膜107に対して高く、機械的強度が比較的低い脆い性質のものを使用する。

【0055】次に、本発明の研磨方法では、金属膜107の凸部に形成された不動態膜108のみを選択的に除去する(プロセスPR5)。不動態膜108の選択的な除去は、上記の研磨装置1によって行う。なお、使用するスラリーSLには、銅に対する研磨レートの高いスラリーを用いる。たとえば、過酸化水素、硝酸鉄、ヨウ素酸カリウム等をベースとした水溶液にアルミナ、シリカ、マンガン系の研磨微粒を含むものを使用する。まず、ウェーハWを研磨装置1のウェーハテーブル2にチャッキングし、電解液ELおよびスラリーSLをウェーハW上に供給しながら回転する研磨工具3およびスクラブ部材24を回転方向に下降させてウェーハWに接触または接近させ、ウェーハWをX軸方向に所定の速度パターンで移動させて研磨加工を行う。また、研磨工具3と電極板23との間に直流ハルス電圧を印加する。なお、スラリーSLのベースとなる水溶液に電解液SLの機能を持たせることにより、スラリーSLのみをウェーハW上に供給してもよい。

【0056】ここで、図17は上記の状態にあるスクラブ部材24付近における研磨プロセスを示す概念図であり、図18は研磨工具3付近における研磨プロセスを示す概念図である。図17に示すように、スクラブ部材24付近では、回転する電極板23の溝部23bからスラリーSLおよび電解液ELが供給されて、スラリーSLおよび電解液ELはスクラブ部材24を通過してスクラブ部材24の全面からウェーハW上に供給される。金属膜107上に形成された不動態膜108は、電解液ELによる電解作用を受けないため電解液EL中への金属膜107を構成する銅の溶出は抑制された状態にある。このため、金属膜107には電流がほとんど流れず、上記の電流計62のモニタした電流値は、低く安定したままである。図25は、本実施形態の電解液合研磨プロセスにおいて電流計62でモニターした電流値の一例を示すグラフである。図25に示す電流値の開始位置付近が上記の状態である。

【0057】スクラブ部材24の回転にしたがって、機械的除去作用あるいはスラリーSLに含まれる、たとえば、酸化アルミニウムからなる研磨微粒PTの機械的除去作用によって不動態膜108の高い部分、すなわち、金属膜107の凸部上の不動態膜108から機械的に除去されていく。一方、図18に示すように、研磨工具3付近では、研磨工具3の機械的除去作用、あるいは、研磨微粒PTの機械的除去作用によって金属膜108に存在する不動態膜108が高い部分から除去される。

【0058】このようにして、たとえば、図19に示すように、金属膜107の凸部上に形成された不動態膜108が選択的に除去されると、不動態膜108が選択的

に除去された部分から金属膜107が表面に露出する。

【0059】金属膜107が表面に露出すると、凸部である金属膜107の露出部分が選択的に溶出する（プロセスP5）。このときの電解液E1の作用は、図18に示すように、不動態膜108が除去された部分である金属膜107の凸部は、金属膜107を構成する銅が電解作用によって銅イオン Cu^{2+} として電解液E1中に溶出する。これによって、金属膜107中にはマイナス電子 e^{-} が流れ、このマイナス電子 e^{-} は、図17に示したように、金属膜107の表面から電解液E1を通して電極板23に流れ、上記した電流1」となる。

【0060】上述したように、金属膜107を構成する銅は、不動態膜108に比べて電気抵抗が低く電流密度が増すため、集中的な電解作用を受け選択的に溶出がおり、平坦化が加速される。また、電解液E1を介して通電するため、陽極としての金属膜107と陰極としての研磨工具3の電位差が一定の場合、極間距離が短い、すなわち、電気抵抗値が低いほうが極間に流れる電流値が大きくなる。このため、陰極としての研磨工具3に対して、陰極としての金属膜107の凹凸による電極間距離の異なる金属膜107の凸部のなかでも高い部分のほうから極間距離が短く電気抵抗が低い方があれば、電流密度の違いから高い順に溶出速度が大きくなる効率的な平坦化が進行する。このとき、図25において、P1で示すように、上記の電流計62のモニタした電流値は上昇しはじめる。このような作用によって、金属膜107の凸部は、機械的平坦化に比べて、はるかに高効率に平坦化が行われる。

【0061】上記の作用によって、金属膜107の凸部がほぼ完全に平坦化されるまで選択的な電解複合研磨が完了した金属膜107の表面は、たとえば、図20に示すように、金属膜107の凹部であった部分に残存する不動態膜108と金属膜107の凸部が除去された銅の新生面の複合面になる。

【0062】続いて、図21に示すように、この金属膜107の表面に研磨工具3およびスラリーSL中の研磨砥粒PTにより行われる機械的除去と電解液E1による電解作用が複合した電解複合研磨が進行する（プロセスP6）。このとき、残存する不動態膜108の機械的強度は上述したように銅の新生面に比べて低いため、不動態膜108が電解複合研磨されるとき、主に機械的作用により除去され、その下にある銅表面が露出し、その面積に比例して電解作用が増大する。不動態膜108が完全除去された時点で金属膜107を構成する銅の表面積は最大となる。これと同時に、電流計62でモニタした電流は、図25においてP1の位置から上昇した電流値は、不動態膜108の除去に伴って上昇した後、銅の表面積が最大となるP2で示す時点で最大値となる。ここまでのプロセスによって、金属膜107の表面の初期凹凸の平坦化は完了する。

【0063】このように、本実施形態の電解複合研磨は、電気化学的に研磨レートをアシストされた研磨であるため、通常の化学機械研磨に比べて低い加工圧力で研磨を行うことができる。このことは、単純な機械的研磨として比較してもスクラッチの低減、段差緩和性能、デイスシングやエロージョンの低減などの面で非常に有利である。さらに、低い加工圧力で研磨を行うことができるため、機械強度が低く通常の化学機械研磨では破壊されてしまい易い、有機系の低誘電率膜や多孔質低誘電率絶縁膜を層間絶縁膜102に用いた場合に非常に有利である。

【0064】上記の金属膜107の電解複合研磨が進行して、余分な金属膜107が除去されると、図22に示すように、バリア膜105が露出する（プロセスP8）。このとき、電流計62のモニターする電流は、図25のP2で示す金属膜107上の不動態膜108がすべて除去された時点より最大値をとり、図25のP3で示すバリア膜105が露出する時点まで略一定の値をとる。バリア膜105が露出すると、たとえば、Ta、Ti、Ta₂N、Ti₂N等の材料を使用した場合には、その電気抵抗が銅に比べて大きいので、たとえば、図25のバリア膜105の露出が開始するP3で示す時点から電流計62でモニターした電流値が低下しはじめる。この状態では、金属膜107の不均一分の銅膜が残留する状態であり、この状態で研磨加工を一旦停止する。この研磨加工の停止は、図25のP4で示すように電流値が所定の値まで下がったことをコントローラ55が判断し、研磨装置1の研磨動作を停止させる。

【0065】次いで、バリア膜105を除去する（プロセスP9）。このバリア膜105を除去するプロセスでは、上記の銅から構成される金属膜107に対して研磨レートの高いスラリーSLではなく、Ta、Ta₂N、Ti、Ti₂N等の材料から形成されたバリア膜105に対して研磨レートが高く、金属膜107に対して研磨レートの低いスラリーSLを使用する。すなわち、バリア膜105と金属膜107の研磨レートの選択比ができるだけ大きなスラリーSLを使用する。

【0066】さらに、オーバーポリッシュによるデイスシング、エロージョンの発生を抑制する観点等から、電解電源61の出力電圧を上記のプロセスよりも小さくしてバリア膜105の研磨除去を行う。また、研磨工具3の加工圧力も上記のプロセスよりも小さくするのが好ましい。また、電解電源61の出力電圧を小さくすること、および、バリア膜105を除去すると層間絶縁膜102が表面に露出することから、電解電流の値は小さくなるので、上記の電流計62による電解電流のモニタに代えて、上記の抵抗計63によってスクラップ部材24と研磨工具3との間に電気抵抗をモニターする。

【0067】バリア膜105を除去すると、図23に示すように、層間絶縁膜102が表面に露出する（プロセ

ステップ10) 層間絶縁膜102が露出すると、図23に示すように、この露出部分には、陽極として表面に通電するための金属膜107やバリア膜105がないため、スクラフ部材21による通電が遮断され、層間絶縁膜102の露出部分での電解作用が停止する。このとき、抵抗計63によってモニターした電気抵抗値は増加しはじめる。

【0068】ここで、金属膜107の残存部分とバリア膜105の露出部分との間で、上記した金属膜107の凸部の段差緩和の場合と同様に、すなわち、不倒態膜108の代りにバリア膜105を電気抵抗の高い部分として、金属膜107の残存部分への電流密度の集中がおこり選択的に金属膜107の残存部分は溶出除去される。電解作用の停止した部分には、研磨工具3とスラリーS1による機械的な材料除去作用のみが主体的に働く。

【0069】ところで、通常の化学機械研磨では、バリア膜105および金属膜107の層間絶縁膜102に対する研磨レート選択比をできるだけ大きくし、そのレートをマージンとして層間絶縁膜102の上面の寸法精度を確保しようとしている。このため、金属膜107のディッシングは避けられない構成となっている。また、選択比を低く設定すればディッシングはある程度少なくすることができるが、寸法精度は、ウェーハ面内除去量分布の均一性に依存するため、バリア膜105および金属膜107の除去が十分ではない場合も発生する。このため、バリア膜105および金属膜107が層間絶縁膜102の上面に残存した状態であるアンダーホリッシュを防ぐためには、除去量の面内不均一分のオーバーホリッシュが必要となり、このオーバーホリッシュによるエロージョンの悪化は本質的に避けられない。一方、本実施形態では、ウェーハWの面内均一性をある程度確保しておけば、層間絶縁膜102上に残るバリア膜105、あるいは、金属膜107の残存部分には電解作用が働くことで高効率除去され、層間絶縁膜102の露出部分から溶出が停止する。このため、層間絶縁膜102の寸法精度は自動的に確保され、ディッシング、エロージョンの発生が抑制される。

【0070】上記のようにして、たとえば、Ta、Ta₂N₅、Ti、TiN等の材料から形成されたバリア膜105を完全に除去することができるとともに、オーバーホリッシュによるディッシング、エロージョンの発生を抑制することができる。また、上述したバリア膜105の除去プロセスでは、絶対電流値は低く、機械的負荷も軽く設定することで除去速度は遅くなるが、残存する膜厚が不均一な部分の残留分の銅膜からなる金属膜107が少なければ、バリア膜105は金属膜107に比べて薄いためバリア膜105の除去量自体は小さく、このプロセスにおいてバラツキ・不均一があったとしてもディッシング、エロージョンの絶対値は無視できる程度に少な

くでき、処理時間も無くすることができる。さらに、本実施形態に係る研磨方法は、機械的研磨に加えて電気化学的作用が付加された複合加工であるため、平坦化した表面はダメージが少なく機械的にも平滑な面を得ることができる。

【0071】次いで、抵抗計63でモニターした電気抵抗値に基づいて、電気抵抗値が最大値すなわち配線形成が完了した時点でバリア膜105を除去するプロセスを終了する(プロセスPR11)。コントローラ5は電気抵抗値の値を判断して、研磨装置1の加工動作を停止させる。なお、研磨加工を終了する前に、電解作用を付加したままの状態、研磨工具3をウェーハWの表面に接触させず、例えば、100nm程度上を通過させることで、機械的研磨は行わず、電解作用のみによるダメージフリーの表面を形成することができる。これにより、図23に示すように、層間絶縁膜102中には配線109およびコンタクト110が最終的に形成される。

【0072】次いで、配線109およびコンタクト110が形成された半導体装置に対してフラッシングを行う(プロセスPR12)。このフラッシングプロセスは、配線109およびコンタクト110が形成された後、直ぐに洗浄薬液、酸化防止剤をウェーハWの表面に供給しながら、ウェーハWには通電せず、図24に示すように、研磨工具3にプラスのバース電圧を印加し、純水洗浄、薬液洗浄を行い、ウェーハWの表面に存在するスラリーS1やパーティクルを除去する。本実施形態では、フラッシングを行う以前にも、スラリーS1に含まれる、たとえば、アルミナからなる研磨砥粒PTは分散性をよくするために正に帯電させているため、銅からなる金属膜107表面に機械的に衝突して除去加工に寄与したのち摩滅せずに残留した場合にも、陽極としての金属膜107を構成する銅の表面に埋没することではなく、図23に示したように、陰極としての研磨工具3の表面に再付着して次の加工に寄与する。さらに、正に帯電したパーティクルも陰極としての研磨工具3の表面に引き寄せられるため、銅の表面に埋没することはない。一方、ウェーハWの表面に残存して負に帯電しているパーティクルも上記のフラッシングによって、ウェーハWの表面から除去することができる。また、研磨砥粒PTが負に帯電したスラリーS1を使用した場合にも同様に除去できる。配線形成材料が銅である場合、酸化されやすく、銅表面を変質させずに、金属イオンやパーティクルを除去する必要があるが、本実施形態では、予め研磨砥粒PTを正に帯電させておき、かつ、フラッシングによってこの問題が解消される。なお、研磨砥粒として、酸化アルミニウム(アルミナ)を例として挙げたが、酸化セリウム、シリカ、酸化ゲルマニウムなどを使用した場合にも同様である。

【0073】以上のように、本実施形態に係る半導体装置の製造方法によれば、絶縁膜102内に形成した配線

用清配線およびコンタクトホールを埋め込む金属膜107に不動態膜108を形成し、金属膜107の凸部に形成された不動態膜108を選択的に除去し、残った不動態膜108をマスクとして表面に露出した金属膜107を電解研磨によって選択的に除去し、かつ電流密度に集中によって集中的に除去することで、通常のCMPに比べてはるかに高能率に初期凹凸を平坦化することができる。また、初期凹凸が平坦化された金属膜107は、電解研磨と化学機械研磨の複合した電解複合研磨によって除去されるため、通常のCMPに比べてはるかに高能率に余分な金属膜107を除去できる。このため、研磨工具3の加工圧力を低く設定しても十分な研磨レートが得られ、金属膜107へのダメージを軽減できるとともに、デッシングやエロージョンの発生を抑制することができる。

【0071】また、本実施形態に係る半導体装置の製造方法によれば、余分な金属膜107を除去してバリア膜105が露出した時点で、研磨を停止し、スラリーSLをバリア膜105に対して研磨レートの高いものに変更し、電解電源61の出力電圧等の研磨条件を変更して余分なバリア膜105を除去を行うため、余分なバリア膜105を確実に除去でき、オーバーポリッシュが必要な場合にも、デッシングやエロージョンの発生量を小さく抑えることができる。

【0075】また、本実施形態に係る半導体装置の製造方法によれば、金属膜の研磨を電解複合研磨によって高能率に行うため、研磨工具3の加工圧力を低圧力にすることができるため、たとえば、低消費電力化および高速化等の観点から誘電率を低減するために層間絶縁膜102として機械的強度が比較的低い有機系低誘電率膜や多孔質低誘電率絶縁膜を使用した場合にも、これらの絶縁膜へのダメージを低減することができる。

【0076】上述した実施形態では、金属膜の研磨加工量の絶対値は、電解電流の積算量と研磨工具3のウェーハWを通過する時間で制御できる。上述した実施形態では、銅による配線形成プロセスの場合を説明したが、本発明はこれに限定されることなく、タングステン、アルミニウム、銀等の種々の金属配線形成プロセスに適用可能である。

【0077】また、上述した実施形態では、スラリーSLを用いた化学機械研磨と電解液ELを用いた電解研磨とを複合した電解複合研磨の場合について説明したが、本発明はこれに限定されない。すなわち、本発明は、スラリーSLを用いずに、電解液ELの電解研磨と研磨工具3の研磨面3aによる機械研磨によって電解複合研磨を行うことも可能である。

【0078】また、上述した実施形態では、研磨工具3と電極板23との間を流れる電流値をモニターし、この値に基づいてバリア膜105が露出するまでの研磨プロセスを管理したが、全ての研磨プロセスをモニターした

電流値で管理することも可能である。同様に、上述した実施形態では、研磨工具3と電極板23との間の電気抵抗値をモニターし、この値に基づいて、バリア膜105の除去プロセスのみの管理を行う構成としたが、全ての研磨プロセスをモニターした電気抵抗値で管理することも可能である。

【0079】変形例1

図26は、本発明に係る研磨装置の1変形例を示す概略図である。上述した実施形態に係る研磨装置1では、ウェーハW表面への通電を、導電性の研磨工具と、スクラブ部材24を備えた通電板23とによって行った。図26に示すように、ホイール状の研磨工具401は、研磨装置1の場合と同様に導電性を持たせるとともに、ウェーハWをチャッキングし回転させるウェーハテーブル402にも導電性を持たせる構成としてもよい。研磨工具401への給電は、上述した実施形態と同様の構成で行う。この場合には、ウェーハテーブル402への通電は、ウェーハテーブル402の下部にロータリージョイント403を設け、ロータリージョイント403によって回転するウェーハテーブル402への通電を常に維持する構成とすることで、電解電流の供給を行うことができる。

【0080】変形例2

図27は、本発明に係る研磨装置の他の変形例を示す概略図である。ウェーハWをチャッキングし、回転させるウェーハテーブル502は、ウェーハWをウェーハWの周囲に設けたリテーナリング504によって保持している。研磨工具501には、導電性を持たせるとともに、リテーナリング504にも導電性を持たせ、研磨工具501には上述した実施形態と同様の構成で給電する。また、リテーナリング504は、ウェーハWに形成された上記のバリア層部分まで覆い通電する。さらに、リテーナリング504には、ウェーハテーブル502の下部に設けられたロータリージョイント503を通じて給電する。なお、研磨工具501がウェーハWに接触しても、エッジの部分でリテーナリング504の厚さ以上の隙間が維持できるように研磨工具3の傾斜量を大きくしておくことで、研磨工具501とリテーナリング504との干渉を防ぐことができる。

【0081】変形例3

図28は、本発明に係る研磨装置の他の実施形態を示す概略構成図である。図28に示す研磨装置は、従来型のCMP装置に本発明の電解研磨機能を付加したものであって、定盤201上に研磨パッド(研磨布)202が貼着された研磨工具の研磨面にウェーハチャック207によってチャッキングされたウェーハWの全面を回転させながら接触させてウェーハWの表面を平坦化する研磨装置である。研磨パッド202には、陽極電極204と陰極電極203とが放射状に交互に配置されている。また、陽極電極204と陰極電極203とは絶縁体206

によって電氣的に絶縁されており、陽極電極204と陰極電極203は、定盤201側から通電される。これら陽極電極204と陰極電極203と絶縁体206とによって研磨ヘッド202は構成されている。また、ウェーハチャック207は、絶縁材料から形成されている。さらに、この研磨装置には、研磨ヘッド202の表面に電解液E1およびスラリーS1を供給する供給部208が設けられており、電解研磨および化学機械研磨を複合させた電解複合研磨が可能になっている。

【0082】ここで、図29は、上記構成の研磨装置による電解複合研磨動作を説明するための図である。なお、ウェーハW表面には、たとえば、銅膜210が形成されているものとする。図29に示すように、電解複合研磨中には、ウェーハW表面に形成された銅膜210と研磨ヘッド202の研磨面との間には、電解液E1およびスラリーS1が介在した状態で、陽極電極204と陰極電極203との間に直流電圧が印加され、電流Iが陽極電極204から電解液E1を通過して銅膜210内を伝って再び電解液E1を通過して陰極電極203に流れる。このとき、図29に示す円G内の付近では、電解作用によって銅膜210が溶出するとともに、銅膜210は研磨ヘッド202とスラリーS1による機械的除去作用によってさらに除去される。

【0083】このような構成とすることにより、上述した実施形態に係る研磨装置1と同様の効果が奏される。なお、研磨ヘッドに設ける陽極電極、陰極電極の配置は図28の構成に限定されるわけではなく、たとえば、図30に示すように、線状の複数の陽極電極222を縦横に等間隔に配列し、陽極電極222によって囲まれる各矩形領域に陰極電極223を配置し、陽極電極222と陰極電極223とを絶縁体224で電氣的に絶縁した研磨ヘッド221としてもよい。さらに、たとえば、図31に示すように、半径がそれぞれ異なる環状の陽極電極242を同心状に配置し、各陽極電極242間に形成される環状領域に陰極電極243をそれぞれ配置し、陽極電極242と陰極電極243とを絶縁体244で電氣的に絶縁した研磨ヘッド241としてもよい。

【0084】

【発明の効果】本発明によれば、機械研磨と電解研磨との複合作用によって金属膜を研磨するので、機械研磨による金属膜の平坦化の場合に比べて、非常に高能率に金属膜の凸部の選択的除去および平坦化が可能となる。また、本発明によれば、研磨工具を陰極として通電するため、予め正に帯電したパーティクルや研磨剤中の研磨砥粒が研磨工具に引き寄せられ、ウェーハ表面へ残留するのを防止することができ、歩留りの向上を図ることができる。また、本発明によれば、高能率に金属膜の除去が可能となるので、比較的低い研磨圧力でも十分な研磨レートが得られ、研磨した金属膜にスクラッチ、ディッシング、エロージョン等が発生するのを抑制することがで

きる。さらに、本発明によれば、比較的低い研磨圧力でも十分な研磨レートが得られたため、半導体装置の低消費電力化および高速化等の観点から誘電率を低減するために層間絶縁膜として機械的強度が比較的低い有機系低誘電率膜や多孔質低誘電率絶縁膜を使用した場合にも、容易に適用可能である。また、本発明によれば、層間絶縁膜に残るバリや膜、あるいは、金属の部分は電解作用が働くことで効率的に除去され、絶縁膜の露出部分から溶出が停止するため、研磨の停止精度を自動的に確保することができる。ディッシング、エロージョンを抑制することができる。また、本発明によれば、電解電流をモニタリングすることで、研磨プロセスの管理を行うことができ、研磨プロセスの進行状態を正確に把握することが可能となる。また、本発明によれば、研磨工具と電極部材との間の電気抵抗値をモニタリングすることで、電流が流れにくい、または電流が流れない膜と金属膜とを同時に研磨するような場合でも、研磨プロセスを正確に管理することができる。

【図面の簡単な説明】

【図1】本発明の研磨装置の一実施形態の構成を示す図である。

【図2】図1の研磨装置のヘッド部の詳細を示す拡大図である。

【図3】(a)は電極板23の構造の一例を示す下面図であり、(b)は電極板23と、通電軸20、スクラブ部材24および絶縁部材1との位置関係を示す断面図である。

【図4】研磨工具とウェーハとの関係を示す図である。

【図5】研磨工具に対してウェーハをX軸方向に移動させた様子を示す図である。

【図6】ヘッド加工部でウェーハを研磨加工する状態を示す概略図である。

【図7】研磨工具と電極板との関係を示す図である。

【図8】本発明の研磨装置の電解研磨機能を説明するための図である。

【図9】本発明の半導体装置の製造方法の一実施形態に係る製造プロセスを示す工程図である。

【図10】本発明の半導体装置の製造方法の製造プロセスを示す断面図である。

【図11】図10に続く製造プロセスを示す断面図である。

【図12】図11に続く製造プロセスを示す断面図である。

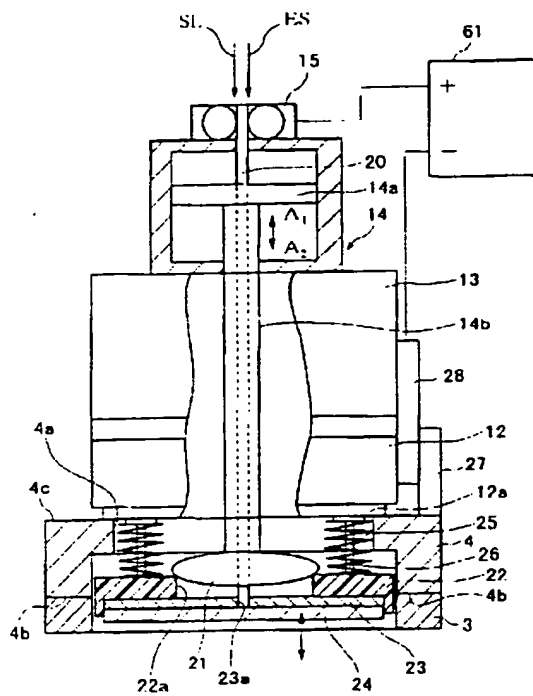
【図13】図12に続く製造プロセスを示す断面図である。

【図14】図13に続く製造プロセスを示す断面図である。

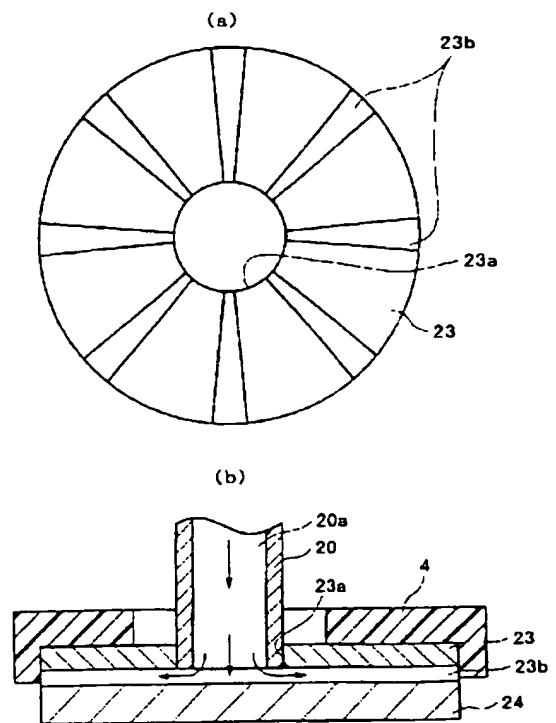
【図15】図14に示す半導体装置の断面構造の拡大図である。

【図16】図14に続く製造プロセスを示す断面図であ

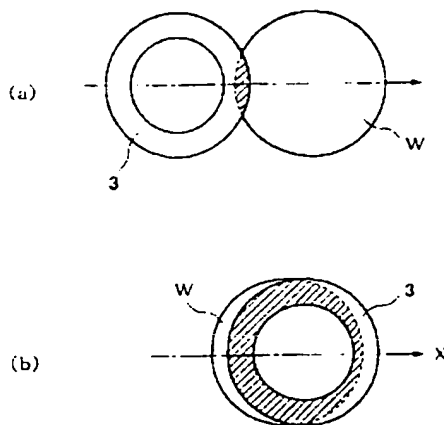
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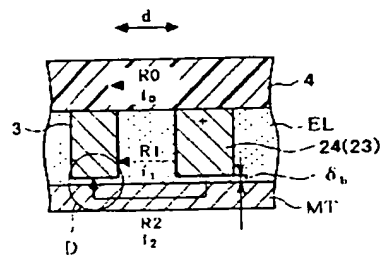
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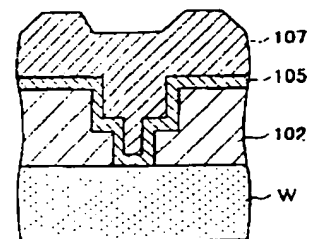
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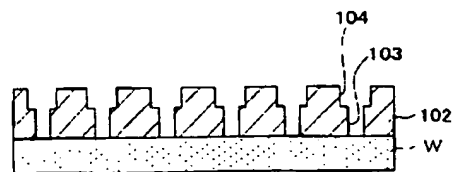
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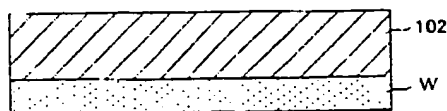
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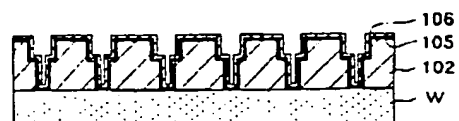
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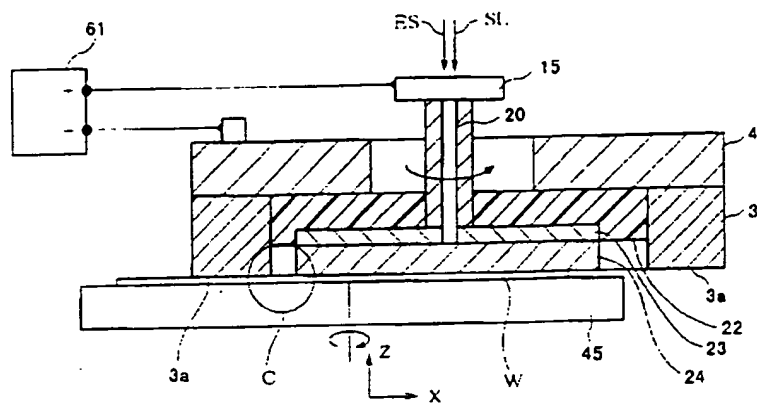
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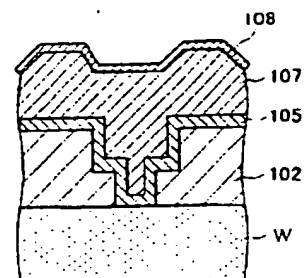
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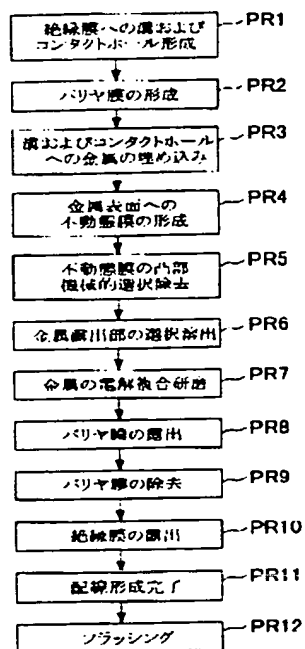
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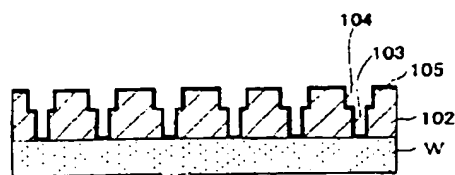
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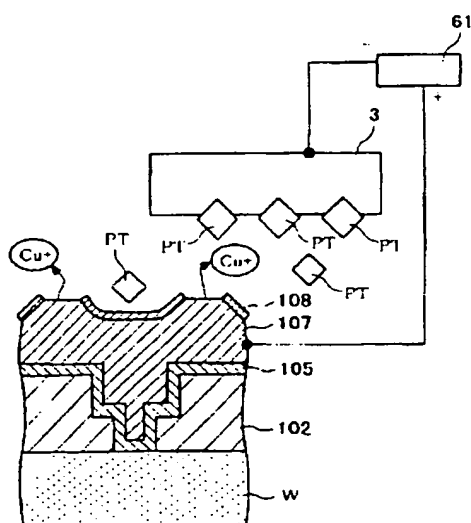
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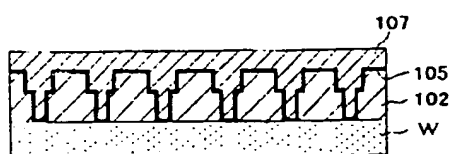
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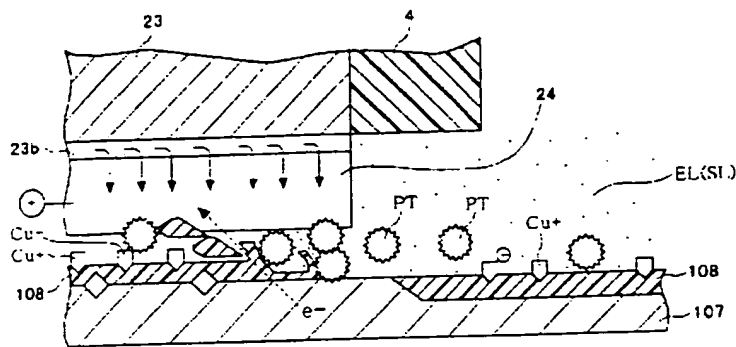
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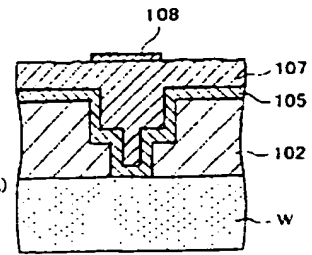
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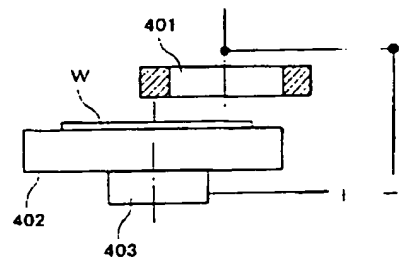
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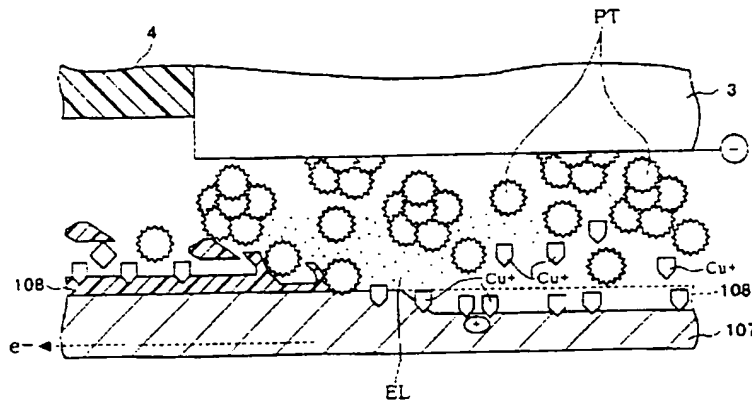
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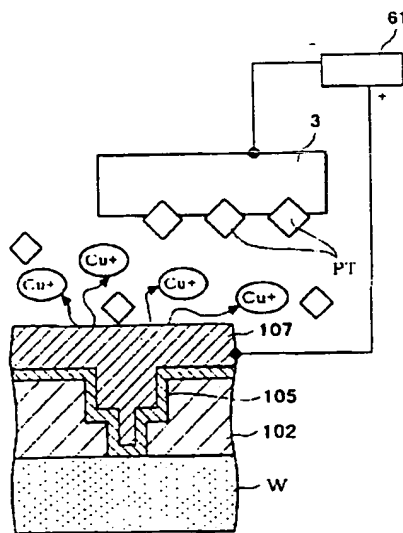
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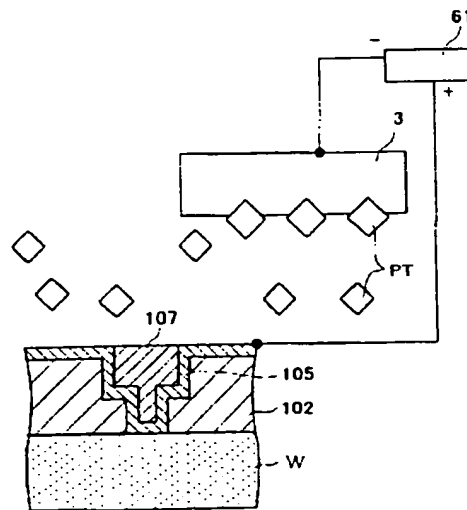
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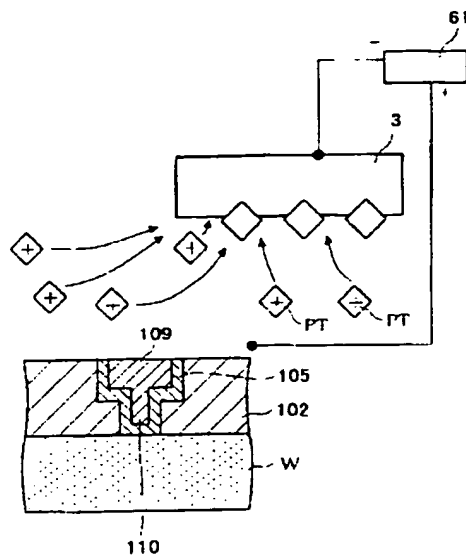
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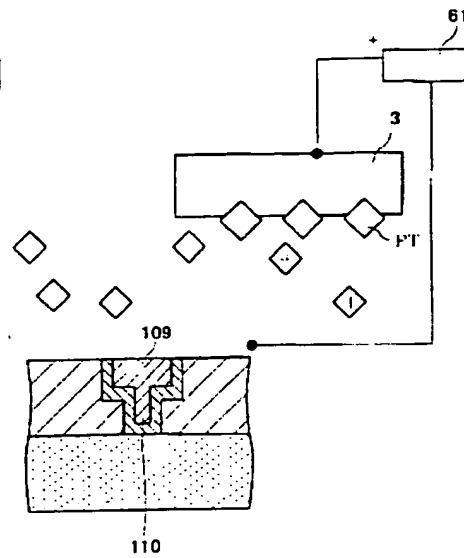
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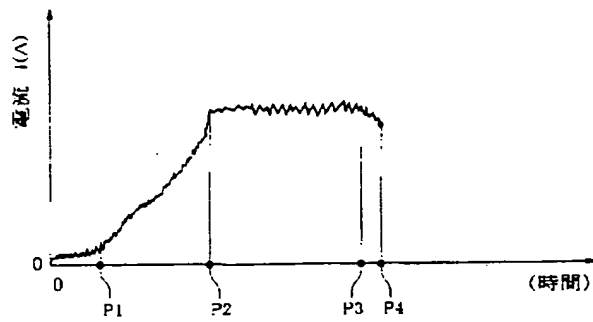
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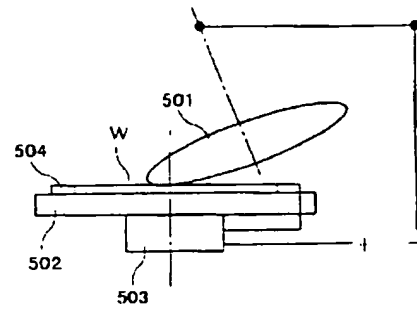
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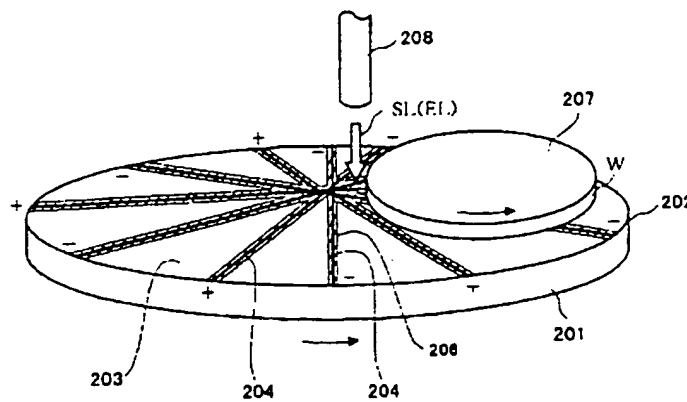
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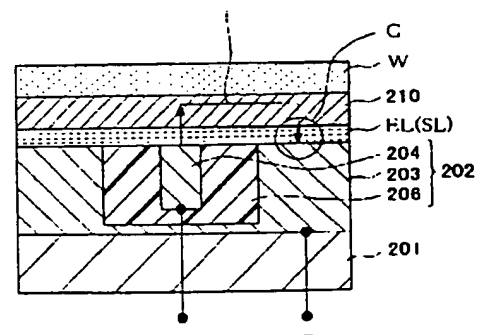
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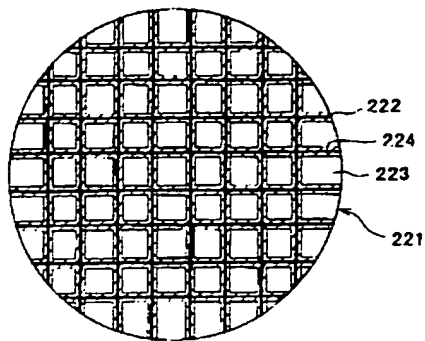
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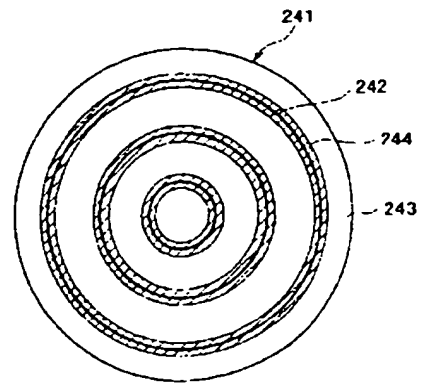
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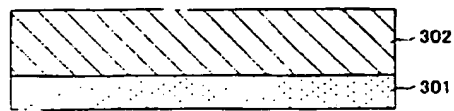
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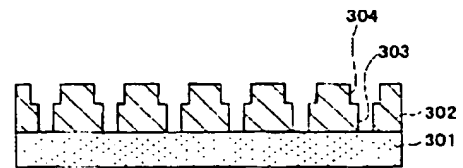
【図31】



【図32】



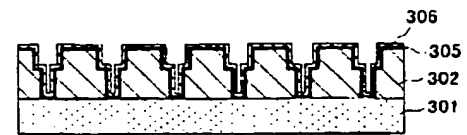
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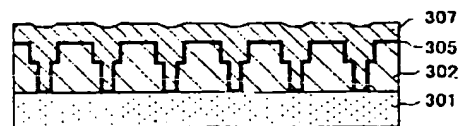
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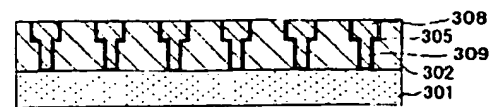
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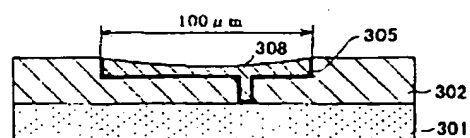
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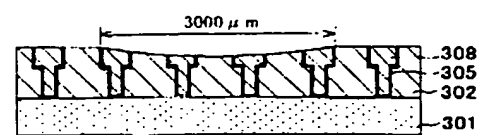
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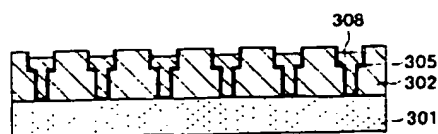
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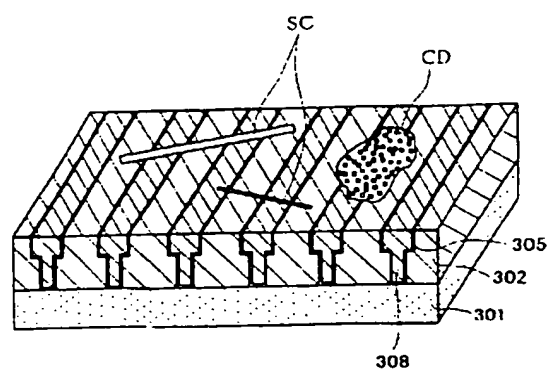
【図39】



【图40】



【图 4-1】



フットボールの続き

(51) Int. Cl. -

識別記号

H O 11. 24.786

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619A

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ドターム(参考) 5F033 HH11 HH18 HH21 HH32 HH33

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PP10 PP27 PP28 PP33 Q009

0037 0046 0018 0019 EE04

SS04 SS13 XX01

5F040 DC01 E103 E108 FC10

5F043 DD14 DD16 EE08 EE14 EE35

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5F110 AA18 A02 NN23 AV35 0019

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NOTICES

17

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2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

- [Claim 1] The manufacture method of a semiconductor device characterized by providing the following. The process which forms the slot for wiring for forming wiring in the insulator layer formed on the substrate. The process which makes a metal membrane deposit on the aforementioned insulator layer so that the aforementioned slot for wiring may be embedded. The process which forms the passive state film which demonstrates the operation which bars the electrolysis reaction of the metal membrane concerned in the front face of the metal membrane deposited on the aforementioned insulator layer. The process which carries out flattening of the irregularity of the front face of the aforementioned metal membrane which removed alternatively the immobility film on the heights which exist in the front face of the aforementioned metal membrane produced by the embedding of the aforementioned slot for wiring among the passive state films formed in the aforementioned metal membrane by mechanical polishing, removed the process which exposes the heights of the metal concerned on a front face, and the heights of the metal membrane which carried out [aforementioned] exposure by electrolytic polishing, and produced by the embedding of the aforementioned slot for wiring.
- [Claim 2] the electrolysis compound polish which compounded electrolytic polishing and mechanical polishing for the excessive metal membrane to which the aforementioned front face exists on the aforementioned insulator layer of the metal membrane by which flattening was carried out -- the manufacture method of a semiconductor device according to claim 1 of having further the process which removes and forms the aforementioned wiring
- [Claim 3] The aforementioned electrolysis compound polish is the manufacture method of a semiconductor device according to claim 2 of compounding electrolytic polishing and chemical machinery polish.
- [Claim 4] The manufacture method of a semiconductor device according to claim 2 characterized by providing the following. After forming the aforementioned slot for wiring, the barrier film which consists of a conductive material for preventing the diffusion to the aforementioned insulator layer of the aforementioned metal membrane so that the aforementioned insulator layer top and aforementioned Mizouchi may be covered forms. The process remove until the aforementioned barrier film exposes the excessive metal membrane which exists on the aforementioned insulator layer to a front face by the aforementioned electrolysis compound polish, after carrying out flattening in the heights of the metal membrane which carried out [aforementioned] exposure. The process removed by the aforementioned electrolysis compound polish until the aforementioned insulator layer exposes to a front face the excessive barrier film which exists on the aforementioned insulator layer.
- [Claim 5] Make the electrolytic solution intervene between the polished surface of the abrasive tools which have conductivity, and the aforementioned passive state film, use the aforementioned metal membrane and a barrier film as an anode plate, and the aforementioned abrasive tools are used as cathode. Impress voltage between the aforementioned metal membrane and a barrier film, and the aforementioned abrasive tools, and the aforementioned abrasive tools are moved to it relatively [front face / of the aforementioned passive state film]. The manufacture method of a semiconductor device according to claim 4 of making the heights of the aforementioned metal membrane exposed from the passive state film which removed alternatively the passive state film formed in the heights of the aforementioned metal membrane, and was removed by the aforementioned selection target eluted by the electrolytic action of the aforementioned electrolytic solution.
- [Claim 6] The manufacture method of a semiconductor device according to claim 5 of making the polar-zone material to which voltage was impressed between the aforementioned abrasive tools contacting or approaching the aforementioned metal membrane and a barrier film, energizing on the aforementioned metal membrane and the aforementioned barrier film, carrying out the monitoring of the current which flows from the aforementioned polar-zone material to the aforementioned abrasive tools via the aforementioned aforementioned metal membrane and the aforementioned barrier film, and managing advance of polish of the aforementioned metal membrane and a barrier film based on the size of the current value concerned.
- [Claim 7] The manufacture method of a semiconductor device according to claim 5 of making the polar-zone material to which voltage was impressed between the aforementioned abrasive tools contacting or approaching the aforementioned metal membrane and a barrier film, energizing on the aforementioned metal membrane and the aforementioned barrier film, carrying out the monitoring of the size of the electric resistance generated between the aforementioned polar-zone material and the aforementioned abrasive tools, and managing advance of polish of the aforementioned metal membrane and a barrier film based on the electric resistance value concerned.
- [Claim 8] The manufacture method of a semiconductor device according to claim 5 of making the chemical-polishing agent containing a polish abrasive grain intervening between the polished surface of the aforementioned abrasive tools, and the aforementioned passive state film, and removing the aforementioned passive state film alternatively.
- [Claim 9] each material which constitutes the aforementioned metal membrane and the aforementioned barrier film -- receiving -- a different chemical-polishing agent with a respectively high polish rate -- using -- the above -- the manufacture method of a semiconductor device according to claim 5 of removing an excessive metal membrane and a barrier film, respectively
- [Claim 10] the above -- the voltage impressed between the aforementioned barrier film and the aforementioned abrasive tools at the process which removes an excessive barrier film -- the above -- the manufacture method of the semiconductor device according to claim 5 made lower than the voltage impressed between the aforementioned metal membranes in a process and the aforementioned abrasive tools which remove an excessive metal membrane
- [Claim 11] The process which the process which forms the aforementioned slot for wiring has the process which forms the contact hole for connecting the impurity-diffusion layer or the wiring formed in the lower layer of the aforementioned insulator layer, and the wiring formed on the insulator layer concerned, and embeds in a metal to the aforementioned slot for wiring with formation of the aforementioned slot for wiring is the manufacture method of a semiconductor device according to claim 2 of embedding a metal to the aforementioned contact hole with the aforementioned slot for wiring
- [Claim 12] The manufacture method of the semiconductor device according to claim 11 which uses copper for the formation material of the aforementioned wiring, and embeds copper at the aforementioned slot for wiring, and a contact hole using an electroplating method.
- [Claim 13] The manufacture method of a semiconductor device according to claim 4 of using either Ta, Ti, TaN and TiN for the formation material of the aforementioned barrier film.

- [Claim 14] The aforementioned passive state film is the manufacture method of the semiconductor device according to claim 1 which consists of an oxide film which oxidized the front face of the aforementioned metal membrane.
- [Claim 15] The manufacture method of the semiconductor device according to claim 14 which supplies an oxidizer to the front face of the aforementioned metal membrane, and forms the aforementioned oxide film.
- [Claim 16] The aforementioned passive state film is the manufacture method of the semiconductor device according to claim 1 which forms the film which consists of material which demonstrates the operation which bars the electrolysis reaction of the metal which constitutes the aforementioned metal membrane on the front face of the aforementioned metal membrane.
- [Claim 17] The aforementioned passive state film is the manufacture method of the semiconductor device according to claim 16 which forms in the front face of the aforementioned metal membrane either the **** water screen, an oil film, an antioxidizing film, the film that consists of a surfactant, the film which consists of a chelating agent and the film which consists of a silane coupling agent.
- [Claim 18] For the aforementioned passive state film, electric resistance is higher than the aforementioned metal membrane, and a mechanical strength is the manufacture method of a semiconductor device given in the low claim 1.
- [Claim 19] The abrasive tools which have a polished surface and have conductivity, and an abrasive-tools rotation maintenance means to rotate and hold the aforementioned abrasive tools focusing on the predetermined axis of rotation, The rotation maintenance means which holds a ground object and is rotated focusing on the predetermined axis of rotation, The move positioning means which carries out move positioning of the aforementioned abrasive tools at the target position of the direction which counters the aforementioned ground object, A relative-displacement means to make the polished surface-ed of the aforementioned ground object, and the polished surface of the aforementioned abrasive tools displaced relatively along with a predetermined flat surface, Polish equipment which has an electrolytic-solution supply means to supply the electrolytic solution on the polished surface-ed of the aforementioned ground object, and an electrolytic-current supply means to supply the electrolytic current which uses the polished surface-ed of the aforementioned ground object as an anode plate, and flows from the aforementioned polished surface-ed to the aforementioned abrasive tools through the aforementioned electrolytic solution by using the aforementioned abrasive tools as cathode.
- [Claim 20] Polish equipment according to claim 19 which has further an abrasive material supply means to supply the chemical-polishing agent which contains a polish abrasive grain in the polished surface-ed of the aforementioned ground object.
- [Claim 21] The aforementioned electrolytic-current supply means is polish equipment [equipped with the DC power supply which impress predetermined potential between an energization means for it to be arranged possible / contact to the polished surface-ed of the aforementioned ground object /, or possible / approach /, and to energize to the polished surface-ed concerned by using the polished surface-ed of the aforementioned ground object as an anode plate, and the aforementioned energization means and the aforementioned abrasive tools] according to claim 1.
- [Claim 22] The aforementioned DC power supply are polish equipment according to claim 21 which outputs the voltage of the shape of a pulse of a predetermined period.
- [Claim 23] It is polish equipment [equipped with the conductive electrode board which the aforementioned abrasive tools consist of a conductive wheel-like member, and the end side where the member concerned is annular constitutes the polished surface, and the aforementioned energization means is isolated with the abrasive tools concerned inside the aforementioned abrasive tools, is prepared in it, is held by the aforementioned rotation maintenance means, and rotates with the aforementioned abrasive tools] according to claim 21.
- [Claim 24] The aforementioned electrode board is polish equipment [equipped with the scrub member which has the field which carries out the scrub of the polished surface-ed concerned to the side which counters the polished surface-ed of the aforementioned ground object] according to claim 23.
- [Claim 25] The aforementioned scrub member is polish equipment according to claim 24 which supplies the electrolytic solution and/or the chemical-polishing agent which are formed from the material which can absorb the chemical-polishing agent containing the aforementioned electrolytic solution and a polish abrasive grain, and can be passed, and are supplied from the aforementioned electrode board side to the polished surface-ed of a ground object.
- [Claim 26] The aforementioned abrasive tools are polish equipment according to claim 21 energized through the energization brush which is held by the conductive member connected with the aforementioned rotation maintenance means, and contacts the aforementioned conductive member which carries out rotation.
- [Claim 27] the electrolyzed metal with which the aforementioned polar-zone material was formed in the polished surface-ed of the aforementioned ground object -- receiving -- ** -- the polish equipment according to claim 23 which consists of a metal
- [Claim 28] Polish equipment according to claim 19 further equipped with a current detection means to detect the value of the electrolytic current which flows from the polished surface-ed of the aforementioned ground object to the aforementioned abrasive tools.
- [Claim 29] Polish equipment [equipped with a resistance detection means to detect the electric resistance between the aforementioned polar-zone material and the aforementioned abrasive tools which went via the polished surface-ed of the aforementioned ground object] according to claim 23.
- [Claim 30] Polish equipment according to claim 29 which has further the control means which control the position of the opposite direction of the aforementioned abrasive tools and the aforementioned ground object based on the detecting signal of the aforementioned current detection means so that the value of the aforementioned electrolytic current becomes fixed.
- [Claim 31] It has the abrasive tools which have the polished surface which contacts while rotating all over the polished surface-ed of a ground object. It is polish equipment which is contacted making the aforementioned polished surface rotate the aforementioned ground object, and carries out flattening polish. Have an electrolytic-solution supply means to supply the electrolytic solution on the aforementioned polished surface, and the aforementioned polished surface is equipped with the anode plate electrode and cathode electrode of the aforementioned ground object which can be energized to a polished surface-ed. Polish equipment which carries out flattening polish of the polished surface-ed of the aforementioned ground object by electrolysis compound polish which compounded electrolytic polishing by the aforementioned electrolytic solution, and mechanical polishing by the aforementioned polished surface.
- [Claim 32] Polish equipment according to claim 31 which carries out flattening polish of the polished surface-ed of the aforementioned ground object by electrolysis compound polish which has further an abrasive material supply means to supply the chemical-polishing agent which contains a polish abrasive grain in the aforementioned polished surface, and compounded the chemical machinery polish by electrolytic polishing by the aforementioned electrolytic solution, the aforementioned polished surface, and the aforementioned abrasive material.
- [Claim 33] Make the electrolytic solution intervene, force the polished surface of conductive abrasive tools, and the front face of the ground object with which the metal membrane was formed in the front face or the inner layer at least, use the aforementioned abrasive tools as cathode, and the front face of the aforementioned ground object is used as an anode plate. The electrolytic current which flows from the front face of the aforementioned ground object through the aforementioned electrolytic solution to the aforementioned abrasive tools is supplied. The polish method which carries out flattening of the metal membrane formed in the aforementioned ground object of the electrolysis compound polish which was made displaced relatively along with a predetermined flat surface, rotating both the aforementioned abrasive tools and the aforementioned ground object, and compounded the aforementioned electrolytic-solution **** electrolytic polishing and mechanical polishing by the aforementioned polished surface.

[Claim 34] The polish method according to claim 33 which carries out flattening of the metal membrane formed in the aforementioned ground object of the electrolysis compound polish which the chemical-polishing agent which contains a polish abrasive grain with the aforementioned electrolytic solution was made to intervene between the aforementioned polished surface and the front face of the aforementioned ground object, and compounded the chemical machinery polish by electrolytic polishing by the aforementioned electrolytic solution, the aforementioned polished surface, and the aforementioned abrasive material.

[Claim 35] The polish method according to claim 33 of the laminating of two or more films which become the aforementioned ground object from a different material being carried out, carrying out the monitoring of the electrolytic current which flows from the front face of the aforementioned ground object to the aforementioned abrasive tools through the aforementioned electrolytic solution which changes with the differences in the electrical property of the material of each aforementioned film, and managing advance of polish based on the size of the electrolytic current concerned.

[Claim 36] The polish method according to claim 33 which impresses the voltage of the shape of a pulse of a predetermined period between the aforementioned abrasive tools and the front face of the aforementioned ground object, and supplies the aforementioned electrolytic current to it.

[Claim 37] The polish method according to claim 33 which is made to approach or contact the front face of the aforementioned ground object with which polar-zone material was supplied to the aforementioned electrolytic solution, and is energized to the front face of the aforementioned ground object.

[Claim 38] The polish method according to claim 37 energized to the metal membrane formed in the aforementioned ground object while rotating the aforementioned polar-zone material with the aforementioned abrasive tools and you made it displaced relatively to the aforementioned ground object.

[Claim 39] The polish method according to claim 37 of managing advance of polish of the aforementioned ground object based on the size of the electric resistance between the aforementioned polar-zone material and the aforementioned abrasive tools which went via the front face of the aforementioned ground object.

[Claim 40] The polish method according to claim 34 of just electrifying the polish abrasive grain contained in the aforementioned abrasive material.

[Claim 41] The polish method characterized by providing the following. The process which forms the passive state film which demonstrates the operation which bars the electrolysis reaction of the metal membrane concerned in the front face of the metal membrane formed in the ground object. The process which the electrolytic solution is made to intervene between the polished surface of conductive abrasive tools, and the aforementioned metal membrane, and forces a polished surface and a metal membrane concerned, and impresses predetermined voltage in between with the aforementioned abrasive tools and the aforementioned metal membrane. The process which removes alternatively the passive state film on the heights which the polished surface of the aforementioned abrasive tools and the metal membrane of the aforementioned ground object were made displaced relatively along with a predetermined flat surface, and were projected to the polished surface of the aforementioned abrasive tools among the aforementioned metal membranes by mechanical polishing of the aforementioned abrasive tools. The process which removes the heights of the metal membrane which the aforementioned passive state film was removed and was exposed to the front face by the electrolytic-polishing operation by the aforementioned electrolytic solution, and carries out flattening of the aforementioned metal membrane.

[Claim 42] The polish method according to claim 41 that make the chemical-polishing agent which contains a polish abrasive grain with the aforementioned electrolytic solution intervene between the aforementioned polished surface and the aforementioned metal membrane, and the chemical machinery polish by the aforementioned polished surface and the aforementioned polish abrasive grain removes the aforementioned passive state film alternatively.

[Claim 43] The aforementioned passive state film is the polish method according to claim 41 which consists of an oxide film which oxidized the front face of the aforementioned metal membrane.

[Claim 44] The aforementioned passive state film is the polish method according to claim 41 which forms the film which consists of material which demonstrates the operation which bars the electrolysis reaction of the metal which constitutes the aforementioned metal membrane on the front face of the aforementioned metal membrane.

[Claim 45] The aforementioned passive state film is the polish method according to claim 41 that electric resistance is high and a mechanical strength is lower than the aforementioned metal membrane.

[Claim 46] The polish method according to claim 41 which an electrode member is made to approach or contact the front face of the aforementioned metal membrane, and is energized to the aforementioned metal membrane.

[Claim 47] The polish method according to claim 46 of managing advance of polish based on the size of the electric resistance between the aforementioned electrode member and the aforementioned abrasive tools.

[Claim 48] The polish method according to claim 42 of just electrifying the polish abrasive grain contained in the aforementioned abrasive material.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the polish equipment and the polish method of carrying out flattening of the concavo-convex field accompanying the multilayer-interconnection structure of a semiconductor device, and the manufacture method of a semiconductor device with multilayer-interconnection structure.

[0002]

[Description of the Prior Art] With high integration of a semiconductor device, and a miniaturization, reduction-izing of detailed-izing of wiring and a wiring pitch and multilayering of wiring are progressing, and the importance of the multilayer-interconnection technology in the manufacture process of a semiconductor device is increasing. On the other hand, although aluminum (aluminum) has been conventionally used abundantly as a wiring material of the semiconductor device of multilayer-interconnection structure, in order to suppress the propagation delay of a signal in the design rule below the latest 0.25-micrometer rule, development of the wiring process which replaced the wiring material with copper (Cu) from aluminum (aluminum) is performed briskly. When Cu is used for wiring, there is a merit that it is compatible in low resistance and high electromigration resistance. In the process which used this Cu for wiring, a metal is embedded at the circuit pattern of the shape of a slot beforehand formed in the layer insulation film, for example, and it is CMP (Chemical Mechanical Polishing: chemical machinery polish). DAMASHIN which removes an excessive metal membrane and forms wiring by the method (damascene) The wiring process called method is leading. Since etching [of wiring] becomes unnecessary [this DAMASHIN method] and the upper layer insulation film will also become flat naturally further, it has the feature that a process can be simplified. Furthermore, not only wiring but a contact hole is opened as a slot at a layer insulation film, and it becomes reducible [a still larger wiring process] by the dual DAMASHIN (dual damascene) method which embeds wiring and a contact hole with a metal simultaneously.

[0003] Here, an example of the wiring formation process by the above-mentioned dual DAMASHIN method is explained with reference to drawing 32 - drawing 37 . In addition, the case where Cu is used as a wiring material is explained. First, as shown in drawing 32 , the layer insulation film 302 which consists of a silicon oxide is formed for example, by the reduced pressure CVD (Chemical Vapour Deposition) method on the substrate 301 which the impurity diffusion field which is not illustrated becomes from semiconductors, such as silicon currently formed suitably. Subsequently, as shown in drawing 33 , the slot 304 in which wiring of the predetermined pattern electrically connected with the impurity diffusion field of the contact hole 303 which leads to the impurity diffusion field of a substrate 301, and a substrate 301 is formed is formed using well-known photolithography technology and etching technology. Subsequently, as shown in drawing 34 , the barrier film 305 is formed in the front face of the layer insulation film 302 and a contact hole 303, and a slot 304. This barrier film 305 forms material, such as Ta, Ti, TaN, and TiN, by the well-known sputter. The barrier film 305 is formed in order to prevent that the material which constitutes wiring is spread in the layer insulation film 302. This is prevented, in order that especially Cu may have a large diffusion coefficient to a silicon oxide and a wiring material may tend to oxidize by Cu, case [whose layer insulation film 302 is / like a silicon oxide].

[0004] Subsequently, on the barrier film 305, as shown in drawing 35 , the Cu film 307 is formed so that the seed Cu film 306 may be formed by predetermined thickness by the well-known sputter, and may be shown subsequently to drawing 36 , and a contact hole 303 and a slot 304 may be embedded by Cu. The Cu film 307 is formed by plating, CVD, the sputter, etc. Subsequently, as shown in drawing 37 , flattening of the excessive Cu film 307 and the barrier film 305 on the layer insulation film 302 is removed and carried out by the CMP method. Wiring 308 and contact 309 are formed of this. A multilayer interconnection can be formed by repeating the above-mentioned process on wiring 308, and performing it.

[0005]

[Problem(s) to be Solved by the Invention] By the way, in the multilayer-interconnection formation process using the above-mentioned dual DAMASHIN method, in the process which removes the excessive Cu film 307 and the barrier film 305 by the CMP method, since removal performances with the layer insulation film 302, the Cu film 307, and the barrier film 305 differed, disadvantageous profit of being easy to generate dishing, erosion (web thinning), a recess, etc. existed in wiring 308. When the large wiring 308 of width of face like about 100 micrometers exists in the design rule of 0.18-micrometer rule, dishing is the phenomenon of the center section of the wiring concerned being removed superfluously and cratering it, and as shown in drawing 38 , since the cross section of wiring 308 runs short if this dishing occurs, it causes poor wiring resistance. When comparatively elastic copper and aluminum are used for a wiring material, it is easy to generate this dishing. As shown in drawing 39 , erosion is the phenomenon in which a portion with high pattern density which is formed in the range of 3000 micrometers by the density whose wiring with a width of face of 1.0 micrometers is 50% will be removed superfluously, and since the cross section of wiring runs short if erosion occurs, it causes poor wiring resistance. As shown in drawing 40 , wiring 308 becomes low on the boundary of the layer insulation film 302 and wiring 308, a recess is the phenomenon which can do a level difference, and since the cross section of wiring runs short also in this case, it causes poor wiring resistance. Furthermore, it is necessary to remove efficiently the Cu film 307 and the barrier film 305, and it is required at the process which removes the excessive Cu film 307 and the barrier film 305 by the CMP method that the polish rate which is the amount of removal per unit time should become 500 or more nm/min. If it is necessary to enlarge the processing pressure force over a wafer and the processing pressure force is enlarged in order to earn this polish rate, as shown in drawing 41 , it will be easy to generate Scratch SC and the chemical damage CD on a wiring front face, they will become it, and it will especially be easy to generate with elastic Cu and elastic aluminum. For this reason, when it became the cause of the fault of opening of wiring, short-circuit, and poor wiring resistance and the processing pressure force was enlarged, disadvantageous profit that the yield of the above-mentioned dishing, erosion, and a recess also became large existed.

[0006] In case this invention carries out flattening of the metal membrane which are made in view of the above-mentioned problem, for example, have multilayer-interconnection structure, such as wiring of a semiconductor device, by polish, it can carry out flattening of the initial irregularity easily, and is excellent in the removal efficiency of an excessive metal membrane, and offers the polish equipment which can suppress generating of superfluous removal and the polish method of metal membranes, such as dishing and erosion, and the manufacture method of a semiconductor device.

[0007]

[Means for Solving the Problem] The abrasive tools which the polish equipment of this invention has a polished surface, and have conductivity, and an abrasive-tools rotation maintenance means to rotate and hold the aforementioned abrasive tools focusing on the predetermined axis of rotation, The rotation maintenance means which holds a ground object and is rotated focusing on the predetermined axis of rotation, The move positioning means which carries out move positioning of the aforementioned abrasive tools at the target position of the direction which counters the aforementioned ground object, A relative-displacement means to make the polished surface-ed of the aforementioned ground object, and the polished surface of the aforementioned abrasive tools displaced relatively along with a predetermined flat surface, It has an electrolytic-solution supply means to supply the electrolytic solution on the polished surface-ed of the aforementioned ground object, and an electrolytic-current supply means to supply the electrolytic current which uses the polished surface-ed of the aforementioned ground object as an anode plate, and flows from the aforementioned polished surface-ed to the aforementioned abrasive tools through the aforementioned electrolytic solution by using the aforementioned abrasive tools as cathode.

[0008] Moreover, it has the abrasive tools which have the polished surface which contacts while the polish equipment of this invention rotates all over the polished surface-ed of a ground object. It is polish equipment which is contacted making the aforementioned polished surface rotate the aforementioned ground object, and carries out flattening polish. Have an electrolytic-solution supply means to supply the electrolytic solution on the aforementioned polished surface, and the aforementioned polished surface is equipped with the anode plate electrode and cathode electrode of the aforementioned ground object which can be energized to a polished surface-ed. Flattening polish of the polished surface-ed of the aforementioned ground object is carried out by electrolysis compound polish which compounded electrolytic polishing by the aforementioned electrolytic solution, and mechanical polishing by the aforementioned polished surface.

[0009] The polish method of this invention makes the electrolytic solution intervene, forces the polished surface of conductive abrasive tools, and the front face of the ground object with which the metal membrane was formed in the front face or the inner layer at least, use the aforementioned abrasive tools as cathode, and the front face of the aforementioned ground object is used as an anode plate. The electrolytic current which flows from the front face of the aforementioned ground object through the aforementioned electrolytic solution to the aforementioned abrasive tools is supplied. You make it displaced relatively along with a predetermined flat surface, rotating both the aforementioned abrasive tools and the aforementioned ground object, and flattening of the metal membrane formed in the aforementioned ground object of the electrolysis compound polish which compounded the aforementioned electrolytic-solution **** electrolytic polishing and mechanical polishing by the aforementioned polished surface is carried out.

[0010] Moreover, the process which forms the passive state film which demonstrates the operation which bars the electrolysis reaction of the metal membrane concerned in the front face of a metal membrane on which the polish method of this invention was formed in the ground object, The process which the electrolytic solution is made to intervene between the polished surface of conductive abrasive tools, and the aforementioned metal membrane, and forces a polished surface and a metal membrane concerned, and impresses predetermined voltage in between with the aforementioned abrasive tools and the aforementioned metal membrane, The polished surface of the aforementioned abrasive tools and the metal membrane of the aforementioned ground object are made displaced relatively along with a predetermined flat surface. The process which removes alternatively the passive state film on the heights projected to the polished surface of the aforementioned abrasive tools among the aforementioned metal membranes by mechanical polishing of the aforementioned abrasive tools, It has the process which removes the heights of the metal membrane which the aforementioned passive state film was removed and was exposed to the front face by the electrolytic-polishing operation by the aforementioned electrolytic solution, and carries out flattening of the aforementioned metal membrane.

[0011] The manufacture method of the semiconductor device of this invention so that the process which forms the slot for wiring for forming wiring in the insulator layer formed on the substrate, and the aforementioned slot for wiring may be embedded The process which forms the passive state film which demonstrates the operation which bars the electrolysis reaction of the metal membrane concerned in the front face of the process which makes a metal membrane deposit on the aforementioned insulator layer, and the metal membrane deposited on the aforementioned insulator layer, The process which mechanical polishing removes [process] alternatively the immobility film on the heights which exist in the front face of the aforementioned metal membrane produced by the embedding of the aforementioned slot for wiring among the passive state films formed in the aforementioned metal membrane, and exposes the heights of the metal concerned on a front face, Electrolytic polishing removes the heights of the metal membrane which carried out [aforementioned] exposure, and it has the process which carries out flattening of the irregularity of the front face of the aforementioned metal membrane produced by the embedding of the aforementioned slot for wiring.

[0012] moreover, the electrolysis compound polish which compounded electrolytic polishing and mechanical polishing for the excessive metal membrane to which the manufacture method of the semiconductor device of this invention exists on the aforementioned insulator layer of the metal membrane to which flattening of the aforementioned front face was carried out -- it removes and has further the process which forms the aforementioned wiring

[0013] By the manufacture method of the semiconductor device of this invention, a passive state film is formed in the metal membrane which has irregularity in a front face, and the heights of a metal membrane are exposed to a front face by removing a passive state film mechanically. The heights of this metal membrane are alternatively eluted by the electrolytic action by the electrolytic solution by using the remaining passive state film as a mask. Consequently, flattening of the initial irregularity of a metal membrane is carried out. Moreover, in case the metal membrane to which flattening of the initial irregularity was carried out is removed by electrolysis compound polish at high efficiency, for example, wiring is formed, the excessive metal membrane which exists on an insulator layer is removed by high efficiency. If an excessive metal membrane is removed and an insulator layer is exposed, the electrolytic action of the portion will stop automatically and the metal membrane embedded in the slot for wiring formed in the insulator layer will not be removed superfluously.

[0014]

[Embodiments of the Invention] Hereafter, the form of operation of this invention is explained with reference to a drawing.

The block diagram 1 of polish equipment is drawing showing the composition of the polish equipment concerning 1 operation gestalt of this invention. Drawing 2 is the important section enlarged view of the processing head section of the polish equipment shown in drawing 1. The polish equipment 1 shown in drawing 1 is equipped with the processing head section 2, the electrolysis power supply 61, the controller 55 that has the function which controls the polish equipment 1 whole, the slurry feeder 71, and the electrolytic-solution feeder 81. In addition, although not illustrated, polish-equipment 1 is installed in a clean room, and the taking-out close port which carries out taking-out close [of the wafer cassette which held the wafer as a ground object] is prepared in the clean room concerned. Furthermore, the wafer carrier robot which delivers a wafer between the wafer cassettes and the polish equipment 1 which were carried in in the clean room through this taking-out close port is installed between a taking-out close port and polish equipment 1.

[0015] The processing head section 2 holds abrasive tools 3, makes it rotate, and is equipped with the abrasive-tools attaching part 11 holding abrasive tools 3, the Z-axis positioning mechanism section 31 which positions the abrasive-tools attaching part 11 to the target position of Z shaft orientations, and the X-axis move mechanism section 41 which is made to hold and rotate the wafer W as a ground object, and moves to X shaft orientations. In addition, the abrasive-tools attaching part 11 corresponds to one example of the abrasive-tools rotation maintenance means of this invention, the X-axis move mechanism section 41 corresponds to one example of the rotation maintenance means of this

invention, and a relative-displacement means, and the Z-axis positioning mechanism section 31 corresponds to one example of the move positioning means of this invention.

[0016] The Z-axis positioning mechanism section 31 is connected with the Z-axis servo motor 18 fixed to the column which is not illustrated, and the supporting structure 12 and the main shaft motor 13, and has the Z-axis slider 16 with which the screw section screwed in ball screw shaft 18a connected to the Z-axis servo motor 18 was formed, and the guide rail 17 installed in the column which holds the Z-axis slider 16 free [movement to Z shaft orientations], and which is not illustrated.

[0017] From the Z-axis driver 52 connected to the Z-axis servo motor 18, drive current is supplied and the rotation drive of the Z-axis servo motor 18 is carried out. Ball screw shaft 18a is prepared along the direction of Z shaft orientations, an end is connected to the Z-axis servo motor 18, and the other end is held free [rotation] by the attachment component prepared in the column which the above does not illustrate. Thereby, the Z-axis positioning mechanism section 31 carries out move positioning of the abrasive tools 3 held at the abrasive-tools attaching part 11 by the drive of the Z-axis servo motor 18 in the arbitrary positions of Z shaft orientations. Positioning accuracy of the Z-axis positioning mechanism section 31 is made into the resolution of about 0.1 micrometers.

[0018] The wafer table 42 on which the X-axis move mechanism 41 acts as the tea king of the wafer W, The supporting structure 45 held free rotation of the wafer table 42] and the drive motor 44 which supplies the driving force which rotates the wafer table 42, The belt 46 which connects a drive motor 44 and the axis of rotation of the supporting structure 45, The processing pan 47 prepared in the supporting structure 45, and the X-axis slider 48 with which a drive motor 44 and the supporting structure 45 were installed, It has the X-axis servo motor 49 by which the pedestal was carried out to the stand which is not illustrated, ball screw shaft 49a connected to the X-axis servo motor 49, and movable member 49b in which the screw section which connects with the X-axis slider 48 and is screwed in ball screw shaft 49a was formed.

[0019] The wafer table 42 adsorbs Wafer W for example, by the vacuum adsorption means. The processing pan 47 is formed in order to collect the used electrolytic solution and liquids, such as a slurry. A drive motor 44 can be driven by supplying drive current from the table driver 53, and the wafer table 42 can be rotated at a predetermined rotational frequency by controlling this drive current. By the drive current supplied from the X-axis driver 54 connected to the X-axis servo motor 49, the X-axis servo motor 49 carries out a rotation drive, and the X-axis slider 48 drives it to X shaft orientations through ball screw shaft 49a and movable member 49b. At this time, the speed control of X shaft orientations of the wafer table 42 becomes possible by controlling the drive current supplied to the X-axis servo motor 49.

[0020] Drawing 2 is drawing showing an example of the internal structure of the abrasive-tools attaching part 11. The abrasive-tools attaching part 11 is equipped with abrasive tools 3, the flange material 4 holding abrasive tools 3, the supporting structure 12 held free [rotation of the flange material 4], the main shaft motor 13 which is connected with main shaft 12a held at the supporting structure 12, and is made to rotate the main shaft 12a concerned, and the cylinder equipment 14 formed on the main shaft motor 13.

[0021] The main shaft motor 13 consists of a direct drive motor, and Rota which this direct drive motor does not illustrate is connected with main shaft 12a held at the supporting structure 12. Moreover, the main shaft motor 13 has the breakthrough by which piston rod 14b of cylinder equipment 14 is inserted in a core. The main shaft motor 13 is driven by the drive current supplied from the main shaft driver 51.

[0022] The supporting structure 12 is equipped with the pneumatic bearing, and holds main shaft 12a free [rotation] by this pneumatic bearing. Main shaft 12a of the supporting structure 12 also has the breakthrough by which piston rod 14b of cylinder equipment 14 is inserted in a core.

[0023] The flange material 4 is formed from the metallic material, it connected with main shaft 12a of the supporting structure 12, the bottom was equipped with opening 4a, and abrasive tools 3 have fixed to soffit side 4b. The upper-limit side 4c side of the flange material 4 is connected with main shaft 12a held at the supporting structure 12, and also rotates the flange material 4 by rotation of main shaft 12a. the conductive energization by which upper-limit side 4c of the flange material 4 was prepared in the side of the main shaft motor 13 and the supporting structure 12 -- it is in contact with the energization brush 27 fixed to the member 28, and the energization brush 27 and the flange material 4 are connected electrically

[0024] It is fixed on the case of the main shaft motor 13, cylinder equipment 14 contains piston 14a, and piston 14a drives it to one sense of the arrows A1 and A2 by the pneumatic pressure supplied for example, in cylinder equipment 14. Piston rod 14b is connected with this piston 14a, and piston rod 14b passed along the center of the main shaft motor 13 and the supporting structure 12, and has projected from opening 4a of the flange material 4. the nose of cam of piston rod 14b -- press -- a member 21 connects -- having -- **** -- this press -- the member 21 is connected in the predetermined range to piston rod 14b by the connection mechanism in which posture change is possible press -- the contact of a member 21 is attained at the periphery section of opening 22a of the electric insulating plate 22 arranged in the position which counters, and it presses an electric insulating plate 22 by the drive to the arrow A 2-way of piston rod 14b

[0025] The breakthrough is formed in the core of piston rod 14b of cylinder equipment 14, the energization shaft 20 is inserted into a breakthrough, and it is fixed to piston rod 14b. up to the rotary joint 15 which the energization shaft 20 is formed from a conductive material, and the upper-limit side penetrated piston 14a of cylinder equipment 14, and was prepared on cylinder equipment 14 -- being extended -- **** -- a soffit side -- piston rod 14b and press -- the member 21 was penetrated, even the electrode board 23 is extended, and it connects with the electrode board 23

[0026] The breakthrough is formed in the core and the energization shaft 20 serves as a supply nozzle with which this breakthrough supplies a chemical-polishing agent (slurry) and the electrolytic solution on Wafer W. Moreover, the energization shaft 20 has played the role which connects a rotary joint 15 and the electrode board 23 electrically.

[0027] The rotary joint 15 connected to the upper-limit section of the energization shaft 20 is electrically connected with the plus pole of the electrolysis electrode 61, and this rotary joint 15 maintains the energization to the energization shaft 20, even if the energization shaft 20 rotates. That is, even if the energization shaft 20 rotates, the potential of plus is impressed from the electrolysis electrode 61 by the rotary joint 15.

[0028] the metal membrane which the electrode board 23 connected to the soffit section of the energization shaft 20 consists of a metallic material, and is especially formed in Wafer W -- ** -- it is formed with the metal an upper surface side holds the electrode board 23 to an electric insulating plate 22 -- having -- **** -- the periphery section of the electrode board 23 -- an electric insulating plate 22 -- fitting in -- **** -- an undersurface side -- a scrub -- the member 24 is stuck

[0029] the bottom view in which drawing 3 (a) shows an example of the structure of the electrode board 23 here -- it is -- drawing 3 (b) -- the electrode board 23, and the energization shaft 20 and a scrub -- it is the cross section showing physical relationship with a member 24 and insulating member 4 As shown in drawing 3 (a), circular opening 23a is prepared in the center section of the electrode board 23, and two or more slot 23b extended to radial [of the electrode board 23] focusing on this opening 23a at a radial is formed. Moreover, as shown in drawing 3 (b), fitting fixing of the soffit section of the energization shaft 20 is carried out at opening 23a of the electrode board 23. the slurry and the electrolytic solution which are supplied by considering as such composition through supply nozzle 20a formed in the core of the energization shaft 20 -- slot 23b -- leading -- a scrub -- it is spread all over a member 24 namely, the electrode board 23, and the energization shaft 20 and a scrub -- supply nozzle 20a by which a slurry and the electrolytic solution were formed in the core of the energization shaft 20 while a member 24 and insulating member 4 rotated -- leading -- a scrub -- if the top side of a member 24 is supplied -- a scrub -- a slurry and the electrolytic solution spread in the whole top side of a member 24 in addition, a scrub -- supply nozzle 20a of a member 24 and the energization shaft 20 corresponds to one example of the abrasive material supply means of this invention, and an electrolytic-solution supply means Moreover, the electrode board 23, the energization shaft 20, and the rotary joint 15 correspond to one example of the energization means of this invention.

[0030] the scrub stuck on the inferior surface of tongue of the electrode board 23 – a member 24 absorbs the electrolytic solution and a slurry, and is formed from the material which can make a bottom side pass these from a top side moreover, this scrub – a member 24 is formed from the material of the shape of a soft brush, sponge-like material, porosity-like material, etc. so that the field which counters Wafer W may be the field which contacts Wafer W and carries out the scrub of the wafer W and a wafer W front face may not be made to generate a scratch etc. For example, the porosity object which consists of resins, such as a urethane resin, melamine resin, an epoxy resin, and a polyvinyl acetal (PVA), is mentioned.

[0031] two or more connection with this electric insulating plate 22 the electric insulating plate 22 is formed from insulating materials, such as ceramics, and cylindrical – the member 26 connects with main shaft 12a of the supporting structure 12 connection – the member 26 is arranged at equal intervals from the medial axis of an electric insulating plate 22 in the predetermined radius position, and is held free movement] to main shaft 12a of the supporting structure 12 For this reason, an electric insulating plate 22 is movable to the shaft orientations of main shaft 12a. moreover -- between an electric insulating plate 22 and main shaft 12a -- each connection -- corresponding to the member 26, it connects by the elastic member 25 which consists of a coil spring

[0032] if high-pressure air is supplied to cylinder equipment 14 and piston rod 14b is dropped to the sense of an arrow A2 by enabling movement of an electric insulating plate 22 to main shaft 12a of the supporting structure 12, and considering as the composition which connects an electric insulating plate 22 and main shaft 12a by the elastic member 25 -- press -- a member 21 -- the stability of an elastic member 25 -- opposing -- an electric insulating plate 22 -- caudad -- depressing -- this -- a scrub -- a member 24 also descends if supply of the high-pressure air from this state to cylinder equipment 14 is stopped -- the stability of an elastic member 25 -- an electric insulating plate 22 -- going up -- this -- a scrub -- a member 24 also goes up

[0033] Abrasive tools 3 have fixed to annular soffit side 4b of the flange material 4. These abrasive tools 3 are formed in the shape of a wheel, and equip the soffit side with annular polished surface 3a. Abrasive tools 3 have conductivity and form it with the material of elasticity nature comparatively preferably. for example, the carbon in which the binder matrix (binder) itself has conductivity -- or it can form from the porosity object which consists of resins, such as a urethane resin containing conductive material, such as a sintered copper and a metal compound, melamine resin, an epoxy resin, and a polyvinyl acetal (PVA) The direct file of the abrasive tools 3 is carried out to the flange material 4 which has conductivity, and they are energized from the energization brush 27 in contact with the flange material 4. namely, the conductive energization prepared in the side of the main shaft motor 13 and the supporting structure 12 -- a member 28 is electrically connected with the minus pole of the electrolysis power supply 61 -- having -- energization -- the energization brush 27 formed in the member 28 -- upper-limit side 4c of the flange material 4 -- contacting -- **** -- thereby -- abrasive tools 3 -- the electrolysis power supply 61 and energization -- it connects electrically through a member 28, the energization brush 27, and the flange material 4

[0034] As abrasive tools 3 are shown in drawing 4, polished surface 3a inclines at the minute angle to a medial axis. Moreover, main shaft 12a of an attachment component 12 as well as the inclination of polished surface 3a inclines to the principal plane of Wafer W. For example, the minute inclination of main shaft 12a can be made by adjusting the installation posture to the Z-axis slider 16 of an attachment component 12. Thus, when the medial axis of abrasive tools 3 inclines at the minute angle to the principal plane of Wafer W and polished surface 3a of abrasive tools 3 is forced on Wafer W by the predetermined processing pressure force F, the efficiency operation field S to the wafer W of polished surface 3a turns into a field of the shape of a straight line extended to radial [of abrasive tools 3], as shown in drawing 4. For this reason, in case Wafer W is moved to X shaft orientations to abrasive tools 3 and polish descent is performed, while moving to drawing 5 (b) from the state of drawing 5 (a), the area of the efficiency operation field S serves as abbreviation regularity. With the polish equipment 1 concerning this operation form, make a part of polished surface 3a of abrasive tools 3 act on the front face of Wafer W partially, the front face of Wafer W is made to scan the effective operation field S uniformly, and the whole surface of Wafer W is ground uniformly.

[0035] The electrolysis power supply 61 is equipment which impresses predetermined voltage between above-mentioned rotary joints 15 and energization brushes 12. impressing voltage between a rotary joint 15 and the energization brush 12 -- abrasive tools 3 and a scrub -- the potential difference occurs between members 24 Preferably, voltage is outputted in the shape of a pulse a fixed period, for example, not the constant voltage power supply that always outputs fixed voltage but the DC power supply which built in the switching regulator circuit are used for the electrolysis power supply 61. Specifically, pulse-like voltage is outputted a fixed period and the power supply which can be changed suitably is used for pulse width. As an example, output voltage used what 2-3A, and pulse width can change [DC150V and a peak output current] into 1, 2, 5, 10, or 20 or 50 microseconds. It considers as the voltage output of the shape of a pulse with the above short width of face for making very small the electrolysis elution volume per one pulse. That is, the spark discharge by sudden change of the electric resistance started when electric discharge, air bubbles, particle, etc. by the sudden change of the distance between electrodes seen when it contacts, the irregularity of the metal membrane formed in the front face of Wafer W, intervene etc. is effective in order to carry out huge elution of the shape of a sudden crater of a metal membrane to prevention or the continuation of a small thing suppressed as much as possible. Moreover, as compared with the output current, since output voltage is comparatively high, a certain amount of margin can be set as a setup of the distance between electrodes. That is, even if the distance between electrodes changes somewhat, since output voltage is high, current-value change is small.

[0036] The electrolysis power supply 61 is equipped with the ammeter 62 as a current detection means of this invention, in order that this ammeter 62 may carry out the monitor of the electrolytic current which flows to the electrolysis power supply 61, it is prepared, and 62s of current-value signals which carried out the monitor is outputted to contra 55. Moreover, the electrolysis power supply 61 is equipped with the ohm-meter 63 as a resistance detection means of this invention, in order that this ohm-meter 63 may carry out the monitoring of the electric resistance between the abrasive tools 3 and the electrode boards 23 which went via the front face of Wafer W based on the current which flows to the electrolysis power supply 61, it is prepared, and it outputs 63s of electric resistance value signals which carried out monitoring to contra 55.

[0037] The slurry feeder 71 supplies a slurry to supply nozzle 20a of the above-mentioned energization shaft 20. The thing which made the solution which has as a slurry the oxidizing power which used a hydrogen peroxide, iron nitrate, the potassium iodate, etc. as the base as an object for polish of a metal membrane contain an aluminum oxide (alumina), a cerium oxide, a silica, a germanium dioxide, etc. as a polish abrasive grain is used. Moreover, a polish abrasive grain is just beforehand electrified, in order to improve dispersibility and to hold a colloidal state.

[0038] The electrolytic-solution feeder 81 supplies the electrolytic solution EL to the processing head section 11. The electrolytic solution EL is a solution which consists of a solvent and a solute separated in ion. As this electrolytic solution, the solution which adjusted the reducing agent to the nitrate or the chloride system can be used.

[0039] A controller 55 has the function which controls the whole polish equipment 1. specifically Output 51s of control signals to the main shaft driver 51, and the rotational frequency of abrasive tools 3 is controlled. Output 52s of control signals to the Z-axis driver 52, and point to point control of Z shaft orientations of abrasive tools 3 is performed. 53s of control signals is outputted to the table driver 53, the rotational frequency of Wafer W is controlled, 54s of control signals is outputted to the X-axis driver 54, and speed control of X shaft orientations of Wafer W is performed. Moreover, a controller 55 controls operation of the electrolytic-solution feeder 81 and the slurry feeder 71, and controls the electrolytic solution EL to the processing head section 2, and supply operation of Slurry SL.

[0040] Moreover, a controller 55 can control the output voltage of the electrolysis power supply 61, the frequency of an output pulse, the width

of face of an output pulse, etc. Moreover, 62s of current-value signals and 63s of electric resistance value signals from the ammeter 62 and ohm-meter 63 of the electrolysis power supply 61 are inputted into a controller 55. A controller 55 can control operation of polish equipment 1 based on 62s of these current-value signals, and 63s of electric resistance value signals. By making 62s of current-value signals into a feedback signal, the Z-axis servo motor 18 controls, or operation of polish equipment 1 is controlled based on the value of the current value specified by 62s of current-value signals, and 63s of electric resistance value signals, and an electric resistance value to stop polish processing so that the electrolytic current obtained from 62s of current-value signals becomes specifically fixed.

[0041] An operator inputs various kinds of data, or the control panel 56 connected to the controller 55 displays 62s of current-value signals and 63s of electric resistance value signals which carried out monitoring.

[0042] Next, the case where the metal membrane formed in the wafer W front face in polish operation by the above-mentioned polish equipment 1 is ground is explained to an example. In addition, the case where the metal membrane which consists of copper is formed in the front face of Wafer W is explained. First, chucking of the wafer W is carried out to the wafer table 45, the wafer table 45 is driven, and Wafer W is rotated at a predetermined rotational frequency. Moreover, the wafer table 45 is moved to X shaft orientations, the abrasive tools 3 attached in the flange 4 are located in the upper predetermined position of Wafer W, and abrasive tools 3 are rotated at a predetermined rotational frequency. the electric insulating plate 22 connected with the flange 4 when abrasive tools 3 were rotated, the electrode board 23, and a scrub -- the rotation drive also of the member 24 is carried out moreover, a scrub -- the press which is pressing the member 24 -- a member 21, piston rod 14b, piston 14a, and the energization shaft 20 also rotate simultaneously

[0043] If Slurry SL and the electrolytic solution EL are supplied to supply nozzle 20a within the energization shaft 20, respectively from the slurry feeder 71 from this state, and the electrolytic-solution feeder 81 -- a scrub -- Slurry SL and the electrolytic solution EL are supplied from the whole surface of a member 24 Abrasive tools 3 are dropped to Z shaft orientations, polished surface 3a of abrasive tools 3 is contacted on the front face of Wafer W, and it is made to press by the predetermined processing pressure force. moreover, the electrolysis power supply 61 is started -- making -- the energization brush 27 -- leading -- the potential of the minus to abrasive tools 3 -- impressing -- a rotary joint 15 -- leading -- a scrub -- the potential of plus is impressed to a member 24

[0044] furthermore, high-pressure air is supplied to cylinder equipment 14, and piston rod 14b is descended in the direction of the arrow A2 of drawing 1 -- making -- a scrub -- the inferior surface of tongue of a member 24 is moved to the position which contacts or approaches Wafer W The wafer table 45 is moved to X shaft orientations by the predetermined rate pattern from this state, and polish processing of the whole surface of Wafer W is carried out uniformly.

[0045] It is the schematic diagram showing the state where drawing 6 dropped abrasive tools 3 to Z shaft orientations in polish equipment 1; and the front face of Wafer W was made to contact here, drawing 7 is an enlarged view in the circle C of drawing 6, and drawing 8 is an enlarged view in the circle D of drawing 7. it is shown in drawing 7 -- as -- a scrub -- by contacting directly the metal membrane MT formed in Wafer W through the electrolytic solution EL supplied on Wafer W, a member 24 is energized as an anode plate and energized as cathode by contacting directly the metal membrane MT in which abrasive tools 3 were also formed at Wafer W through the electrolytic solution EL supplied on Wafer W in addition, it is shown in drawing 7 -- as -- a metal membrane MT and a scrub -- gap deltab exists between members 24 Furthermore, as shown in drawing 8, gap deltaw exists between a metal membrane MT and polished surface 3a of abrasive tools 3. it is shown in drawing 7 -- as -- an electric insulating plate 4 -- abrasive tools 3 and a scrub -- although it intervenes between members 24 (electrode board 23) -- the resistance R0 of an electric insulating plate 4 -- very much -- large -- therefore, a scrub -- current i0 which flows from a member 24 to abrasive tools 3 through an electric insulating plate 4 about 0 -- it is -- a scrub -- to abrasive tools 3, current does not flow through an electric insulating plate 4 from a member 24

[0046] for this reason, a scrub -- current i1 to which the current which flows to abrasive tools 3 flows from a member 24 to abrasive tools 3 via the resistance R1 in the direct electrolytic solution EL It branches to current i2 which flows in the current which flows [be / under / electrolytic-solution EL / passing / it] to abrasive tools 3 again out of the electrolytic solution EL via the metal membrane MT which consists of copper formed in the front face of Wafer W. If current i2 flows on the front face of a metal membrane MT, the copper which constitutes a metal membrane MT will be ionized by the electrolytic action of the electrolytic solution EL, and will be eluted in the electrolytic solution EL.

[0047] here -- the resistance R1 in the electrolytic solution EL -- the scrub as an anode plate -- in proportion to the distance d of a member 24 and the abrasive tools 3 as cathode, it becomes extremely large For this reason, current i1 which flows to abrasive tools 3 via the resistance R1 in the direct electrolytic solution EL by making the distance between electrodes d larger enough than gap deltab and gap deltaw It becomes very small, current i2 becomes large, and a metal membrane MT will carry out the surface course of most electrolytic currents. For this reason, electrolysis elution of the copper which constitutes a metal membrane MT can be performed efficiently. Moreover, since the size of current i2 changes with the sizes of gap deltab and gap deltaw, as mentioned above, it can make current i2 regularly by performing position control of Z shaft orientations of abrasive tools 3, and adjusting the size of gap deltab and gap deltaw by the controller 55. Adjustment of the size of gap deltaw is possible by controlling the Z-axis servo motor 18 by making 62s of current-value signals into a feedback signal so that the electrolytic current obtained from 62s of current-value signals, i.e., current i2, may become fixed. Moreover, the positioning accuracy of Z shaft orientations of polish equipment 1 is fully as high as the resolution of 0.1 micrometers, in addition since it is always maintained uniformly, whenever the execution-[making main shaft 12a incline at a minute angle to the principal plane of Wafer W] touch area S controls the value of an electrolytic current uniformly, it is made as current density is always fixed, and can also make the electrolysis elution volume of a metal membrane regularity.

[0048] as mentioned above, the electrolytic action according the metal which constitutes the metal membrane MT formed in the wafer W which mentioned above the polish equipment 1 of the above-mentioned composition to the electrolytic solution EL -- it has the electrolytic-polishing function which carries out elution removal Furthermore, in addition to this electrolytic-polishing function, the polish equipment 1 of the above-mentioned composition is equipped also with the chemical machinery polish function of abrasive tools 3 and the usual CMP equipment by Slurry SL, and it can also perform grinding Wafer W by compound operation of these electrolytic-polishing function and chemical machinery polish (henceforth electrolysis compound polish). Moreover, the polish equipment 1 of the above-mentioned composition can also perform polish processing by compound operation with mechanical polish and the electrolytic-polishing function of polished surface 3a of abrasive tools 3, without using Slurry SL. Since the polish equipment 1 of the above-mentioned composition can grind a metal membrane by compound operation of electrolytic polishing and chemical machinery polish, it can remove a metal membrane in high efficiency far compared with the polish equipment only using chemical machinery polish or mechanical polishing. Since the high polish rate to a metal membrane is obtained, it becomes possible to suppress low the processing pressure force F over the wafer W of abrasive tools 3 compared with the polish equipment only using chemical machinery polish or mechanical polishing, and generating of dishing and erosion can be suppressed.

[0049] The case where it applies to the wiring formation process by the dual DAMASHIN method of the semiconductor device of multilayer-interconnection structure hereafter about the polish method using the electrolysis compound polish function of the polish equipment 1 concerning this operation Gestair is explained to an example.

[0050] < -- A HREF -- -- -- -- Tokujitu/tjitemdrw -- -- ipdl?N -- 0000 -- -- 237 -- & -- N -- 0500 -- -- one -- E_N -- /-; -- > -- < -- ? -- 88 -- > -- > -- eight -- /-; -- /-; -- & -- N -- 0001 -- -- 152 -- & -- N -- 0552 -- -- nine -- & -- N -- 0553 -- -- 000011 -- -- TARGET -- -- "tjitemdrw" -- > -- drawing 9 -- First, it is TEOS (tetraethylorthosilicate) considering the layer insulation film 102 which consists of a silicon oxide (SiO2) as for example, a source of a reaction on the wafer W with which the impurity diffusion field which is not illustrated is suitably formed, for example,

consists of semiconductors, such as silicon, as shown in drawing 10. It uses and forms by the reduced pressure CVD (Chemical Vapour Deposition) method. Subsequently, as shown in drawing 11, the slot 104 for wiring in which wiring of the predetermined pattern electrically connected with the impurity diffusion field of the contact hole 103 and Wafer W which lead to the impurity diffusion field of the slot 104 for wiring is formed using well-known photolithography technology and etching technology, for example. In addition, the depth of the slot 104 for wiring is about 800nm.

[0051] Subsequently, as shown in drawing 12, the barrier film 105 is formed in the front face of the layer insulation film 102 and a contact hole 103, and the slot 104 for wiring. This barrier film 305 is PVD (Physical Vapor Deposition) which used material, such as Ta, Ti, TaN, and TiN, for the sputtering system, the vacuum evaporation system, etc. By the method, it forms by about 15nm thickness. The barrier film 305 is formed in order to prevent that the material which constitutes wiring is spread in the layer insulation film 102, and in order to raise adhesion with the layer insulation film 102. This is prevented, in order that especially copper may have a large diffusion coefficient to a silicon oxide and a wiring material may tend to oxidize with copper, case [whose layer insulation film 102 is / like a silicon oxide]. The process to the above is the process PR 1 shown in drawing 9.

[0052] Subsequently, as shown in drawing 13, the seed film 106 which consists of the same material as wiring formation material, for example, copper, is formed by about 150nm thickness by the well-known sputter on the barrier film 105 (process PR 2). When copper is embedded in the slot for wiring, and a contact hole, the seed film 106 is formed in order to urge growth of a copper grain. Subsequently, as shown in drawing 14, the metal membrane 107 which consists of copper is formed by about 2000nm thickness on the barrier film 105 so that a contact hole 103 and the slot 104 for wiring may be embedded. Preferably, although a metal membrane 107 is formed by electrolysis plating or the electroless deposition method, you may form it by CVD, the sputter, etc. In addition, the seed film 106 is united with a metal membrane 107 (process PR 3).

[0053] Here, drawing 15 is the enlarged view of the cross section of the semiconductor device in the middle of the manufacture process in which the metal membrane 107 was formed on the barrier film 105. As shown in drawing 15, in the front face of a metal membrane 107, irregularity with a height of about 600nm has occurred for the embedding to a contact hole 103 and the slot 104 for wiring. Although the above process is performed in the same process as usual, it performs removal of the excessive metal membrane 107 which exists on the layer insulation film 102, and the barrier film 105 by the polish method of this invention not by chemical machinery polish but by electrolysis compound polish of above polish equipment 1. Moreover, by the polish method of this invention, in advance of the process by the above-mentioned electrolysis compound polish, as shown in drawing 16, the passive state film 108 is formed in the front face of a metal membrane 107 (process PR 4). This passive state film 108 is a film which consists of material which demonstrates the operation which bars the electrolysis reaction of the metal (copper) which constitutes a metal membrane 107.

[0054] The formation method of the passive state film 108 applies an oxidizer to the front face of a metal membrane 107, and forms an oxide film in it. When the metal which constitutes a metal membrane 107 is copper, a copper oxide (CuO) serves as the passive state film 108. Moreover, it is also possible to form in the front face of a metal membrane 107 either for example, the *** water screen, an oil film, an antioxidizing film, the film that consists of a surfactant, the film which consists of a chelating agent and the film which consists of a silane coupling agent as other methods, and to consider as the passive state film 108. Although especially the kind of passive state film 108 is not limited, to a metal membrane 107, electric resistance is high and uses the thing of the property in which a mechanical strength is comparatively low and weak.

[0055] Next, by the polish method of this invention, only the passive state film 108 formed in the heights of a metal membrane 107 is removed alternatively (process PR 5). Above polish equipment 1 performs alternative removal of the passive state film 108. In addition, a slurry with the high polish rate to copper is used for the slurry SL to be used. For example, what contains the polish abrasive grain of an alumina, a silica, and a manganese system in the solution which used a hydrogen peroxide, iron nitrate, the potassium iodate, etc. as the base is used. First, the abrasive tools 3 which rotate while carrying out chucking of the wafer W to the wafer table 42 of polish equipment 1 and supplying the electrolytic solution EL and Slurry SL on Wafer W and a scrub - drop a member 24 to Z shaft orientations, Wafer W is made to contact or approach, Wafer W is moved to X shaft orientations by the predetermined rate pattern, and polish processing is performed. Moreover, a direct-current pulse voltage is impressed between abrasive tools 3 and the electrode board 23 by making a minus pole and the electrode board 23 into a plus pole at abrasive tools 3. In addition, you may supply Slurry SL on Wafer W by giving the function of the electrolytic solution SL to the solution used as the base of Slurry SL.

[0056] the scrub which is in the state of the above [drawing 17] here -- a member -- it is the conceptual diagram showing the polish process in the 24 neighborhood, and drawing 18 is the conceptual diagram showing the polish process in the abrasive-tools 3 neighborhood it is shown in drawing 17 -- as -- a scrub -- a member -- in the 24 neighborhood, Slurry SL and the electrolytic solution EL supply from slot 23b of the rotating electrode board 23 -- having -- Slurry SL and the electrolytic solution EL -- a scrub -- a member 24 -- passing -- a scrub -- it is supplied on Wafer W from the whole surface of a member 24. Elution of the copper which constitutes the metal membrane 107 to the inside of the electrolytic solution EL has the passive state film 108 formed on the metal membrane 107 in the state where it was suppressed in order not to receive the electrolytic action by the electrolytic solution EL. For this reason, the current value in which current hardly flowed to a metal membrane 107, but the above-mentioned ammeter 62 carried out the monitor has been stabilized low. Drawing 25 is a graph which shows an example of the current value which acted as the monitor with the ammeter 62 in the electrolysis compound polish process of this operation form. Near the starting position of current value shown in drawing 25 is in the above-mentioned state.

[0057] a scrub -- according to rotation of a member 24, it is contained in a mechanical removal operation or Slurry SL, for example, is mechanically removed from the passive state film 108 on the high portion of the passive state film 108, i.e., the heights of a metal membrane 107, by the mechanical removal operation of the polish abrasive grain PT which consists of an aluminum oxide. On the other hand, as shown in drawing 18, in the abrasive-tools 3 neighborhood, the passive state film 108 which exists in a metal membrane 108 by a mechanical removal operation of abrasive tools 3 or mechanical removal operation of the polish abrasive grain PT is removed from a high portion.

[0058] Thus, if the passive state film 108 formed on the heights of a metal membrane 107 is alternatively removed for example, as shown in drawing 19, a metal membrane 107 will be exposed to a front face from the portion from which the passive state film 108 was removed alternatively.

[0059] If a metal membrane 107 is exposed to a front face, it will be alternatively eluted by the amount of [of the metal membrane 107 which is heights] outcrop (process PR 5). As an operation of the electrolytic solution EL at this time is shown in drawing 18, the copper with which the heights of the metal membrane 107 which is the portion from which the passive state film 108 was removed constitute a metal membrane 107 is eluted in the electrolytic solution EL as copper-ion Cu^{+} by the electrolytic action. By this, it is the minus electron e^{-} in a metal membrane 107. - It flows and is this minus electron e^{-} . - Current i_2 which flowed and described above from the front face of a metal membrane 107 to the electrode board 23 through the electrolytic solution EL as shown in drawing 17 It becomes.

[0060] As mentioned above, since electric resistance is low and current density of copper which constitutes a metal membrane 107 increases compared with the passive-state film 108, an intensive electrolytic action is received, elution starts alternatively, and material removal is accelerated. Moreover, in order to energize through the electrolytic solution EL, when the potential difference of the abrasive tools 3 as the metal membrane 107 and cathode as an anode plate is fixed, the current value to which the one where an electric resistance value is lower flows in between very much becomes [the distance between electrodes] short greatly. For this reason, if there is a difference (the distance

between electrodes is [the portion high in the heights of a metal membrane 107] shorter, and electric resistance is low) of the inter-electrode distance by the irregularity of the metal membrane 107 as cathode to the abrasive tools 3 as cathode, efficient flattening to which elution speed becomes large at high order will advance from the difference in current density. At this time, in drawing 25, as shown in P1, the current value in which the above-mentioned ammeter 62 carried out the monitor begins to go up. Compared with mechanical flattening, as for the heights of a metal membrane 107, flattening is far carried out to high efficiency by such operation.

[0061] The front face of the metal membrane 107 which alternative electrolysis compound polish completed by it until flattening of the heights of a metal membrane 107 was carried out nearly completely by the above-mentioned operation turns into a compound side of the new field of the copper from which the heights of the passive-state film 108 which remains into the portion which was the crevice of a metal membrane 107, and a metal membrane 107 were removed, as shown in drawing 20.

[0062] Then, as shown in drawing 21, the electrolysis compound polish which the electrolytic action by the mechanical removal and the electrolytic solution EL which are performed on the front face of this metal membrane 107 by the polish abrasive grain PT in abrasive tools 3 and Slurry SL compounded advances (process PR 7). As the mechanical strength of the passive-state film 108 which remains at this time was mentioned above, when electrolysis compound polish of the passive-state film 108 is carried out compared with a copper new field for a low reason, it is mainly removed by the mechanical work, the copper front face in the bottom of it is exposed, and an electrolytic action increases in proportion to the area. When full removal of the passive-state film 108 is carried out, the surface area of the copper which constitutes a metal membrane 107 serves as the maximum. After the current value to which the current which could come, simultaneously acted as the monitor with the ammeter 62 went up from the position of P1 in drawing 25 goes up with removal of the passive-state film 108, when P2 from which a copper surface area serves as the maximum shows it, it turns into maximum. According to the process so far, flattening of the initial irregularity of the front face of a metal membrane 107 is completed.

[0063] Thus, since electrolysis compound polish of this operation form is the polish electrochemically aided with the polish rate, it can be ground by the low processing pressure force compared with the usual chemical machinery polish. Even if it compares this as simple mechanical polish, it is very advantageous in respect of reduction of a scratch, a level difference relief performance, dishing, reduction of erosion, etc. Furthermore, it is very advantageous, when mechanical strength uses for the layer insulation film 102 the low dielectric constant film of an organic system and porosity low dielectric constant insulator layer which are easy to be destroyed in the low usual chemical machinery polish, since it can grind by the low processing pressure force.

[0064] If electrolysis compound polish of the above-mentioned metal membrane 107 advances and the excessive metal membrane 107 is removed, as shown in drawing 22, the barrier film 105 will be exposed (process P8). At this time, the current in which an ammeter 62 acts as a monitor takes maximum from the time of the passive-state film 108 on the metal membrane 107 shown by P2 of drawing 25 being removed altogether, and it takes the value of abbreviation regularity until the barrier film 105 shown by P3 of drawing 25 is exposed. If the barrier film 105 is exposed, when material, such as Ta, Ti, TaN, and TiN, is used, the current value which acted as the monitor with the ammeter 62 from the time of the electric resistance showing by P3 which exposure of the barrier film 105 of drawing 25 starts since it is large compared with copper will begin to fall, for example. In this state, it is in the state where the copper film for an ununiformity of a metal membrane 107 remains, and polish processing is stopped in this state. As shown in P4 of drawing 25, a controller 55 judges that current value fell to the predetermined value, and a halt of this polish processing stops polish operation of polish equipment 1.

[0065] Subsequently, the barrier film 105 is removed (process PR 9). In the process which removes this barrier film 105, to the barrier film 105 formed to the metal membrane 107 which consists of above-mentioned copper from material, such as not the slurry SL with a high polish rate but Ta, TaN, Ti, TiN, etc., a polish rate is high and uses the slurry SL with a low polish rate to a metal membrane 107. That is, the selection ratio of the polish rate of the barrier film 105 and a metal membrane 107 uses the biggest possible slurry SL.

[0066] Furthermore, from a viewpoint which suppresses generating of dishing by the exaggerated polish, and erosion, output voltage of the electrolysis power supply 61 is made smaller than the above-mentioned process, and polish removal of the barrier film 105 is performed. Moreover, it is desirable to also make the processing pressure force of abrasive tools 3 smaller than the above-mentioned process. moreover, the monitor of the electrolytic current by the above-mentioned ammeter 62 if making small output voltage of the electrolysis power supply 61 and the barrier film 105 are removed, since the layer insulation film 102 will be exposed to a front face and the value of an electrolytic current becomes small – replacing with – the above-mentioned ohm-meter 63 – a scrub – it acts as the monitor of the electric resistance between a member 24 and abrasive tools 3.

[0067] Removal of the barrier film 105 exposes the layer insulation film 102 on a front face, as shown in drawing 23 (process P10). since there are no metal membrane 107 and barrier film 105 for energizing on a front face as an anode plate in a part for this outcrop as shown in drawing 23, when the layer insulation film 102 is exposed – a scrub – energization by the member 24 is intercepted and the electrolytic action for the outcrop of the layer insulation film 102 stops. At this time, the electric resistance value which acted as the monitor with the ohm-meter 63 begins to increase.

[0068] Here, like the case of level difference relief of the heights of the above-mentioned metal membrane 107, instead of the passive-state film 108, concentration of the current density to the residual portion of a metal membrane 107 starts the barrier film 105 as a portion with high electric resistance, and elution removal of the residual portion of a metal membrane 107 is alternatively carried out between parts for the portion into which a metal membrane 107 remains, and the outcrop of the barrier film 105. Into the portion which the electrolytic action stopped, only the mechanical material removal operation by abrasive tools 3 and Slurry SL works actively.

[0069] By the way, in the usual chemical machinery polish, the polish rate selection ratio to the barrier film 105 and the layer insulation film 102 of a metal membrane 107 tends to be enlarged as much as possible, and it is going to secure the dimensional accuracy of the upper surface of the layer insulation film 102 by using the rate difference as a margin. For this reason, dishing of a metal membrane 107 has composition which is not avoided. Moreover, although dishing can be lessened to some extent if a selection ratio is set up low, a dimensional accuracy is generated when removal of the barrier film 105 and a metal membrane 107 is not enough in order to be dependent on the homogeneity of the amount distribution of removal within a water side. For this reason, in order for the barrier film 105 and a metal membrane 107 to prevent the undershirt polish which is in the state which remained on the upper surface of the layer insulation film 102, the exaggerated polish for the ununiformity within a field of the amount of removal is needed, and aggravation of the erosion by this exaggerated polish is not avoided in essence. On the other hand, with this operation gestalt, if the homogeneity within a field of Wafer W is secured to some extent, high efficiency removal will be carried out because an electrolytic action works into the residual portion of the barrier film 105 which remains on the layer insulation film 102, or a metal membrane 107, and elution will stop from a part for the outcrop of the layer insulation film 102. For this reason, the dimensional accuracy of the layer insulation film 102 is secured automatically, and generating of dishing and erosion is suppressed.

[0070] While the barrier film 105 formed from material, such as Ta, TaN, Ti, and TiN, as mentioned above is completely removable, generating of dishing by the exaggerated polish and erosion can be suppressed. Moreover, although current value is low and removal speed becomes slow by setting up a mechanical load lightly absolutely in the removal process of the barrier film 105 mentioned above. If there are few metal membranes 107 which the thickness which remains becomes from the copper film of the residue of an uneven portion. The barrier film 105 is made few to the grade which can disregard the absolute value of dishing and erosion though the amount of removal of the barrier film 105 itself is small since it is thin compared with a metal membrane 107, and there are variation and an ununiformity in this process, and can also shorten the processing time. Furthermore, since the polish method concerning this operation gestalt is compound processing to which the

electrochemical operation was added in addition to mechanical polish, also mechanically, as for the front face which carried out flattening, a damage can acquire a smooth field few.

[0071] Subsequently, when maximum, i.e., wiring formation, is completed by the electric resistance value based on the electric resistance value which acted as the monitor with the ohm-meter 63, the process which removes the barrier film 105 is ended (process PR 11). A controller 55 judges the value of an electric resistance value, and stops processing operation of polish equipment 1. In addition, by not contacting abrasive tools 3 on the front face of Wafer W, for example, passing about 100 micrometers of tops in the state [having added the electrolytic action], before ending polish processing, mechanical polish cannot be performed but the front face of the damage free-lancer only by the electrolytic action can be formed. Thereby, as shown in drawing 23, finally into the layer insulation film 102, wiring 109 and contact 110 are formed.

[0072] Subsequently, Flushing is performed to the semiconductor device with which wiring 109 and contact 110 were formed (process-PR 12). Supplying washing lotion liquid and an antioxidant to the front face of Wafer W immediately, after wiring 109 and contact 110 are formed, as it does not energize to Wafer W but is shown in drawing 24, this Flushing process impresses the pulse voltage of plus to abrasive tools 3, performs pure water washing and medical fluid washing, and removes Slurry SL and the particle which exist in the front face of Wafer W. Since it is contained in Slurry SL, for example, you are making it just charged with this operation gestalt before performing Flushing in order that the polish abrasive grain PT which consists of an alumina may improve dispersibility. When it remains without wearing out after colliding with metal membrane 107 front face which consists of copper mechanically and contributing to removal processing, as it is not buried in the front face of the copper which constitutes the metal membrane 107 as an anode plate and was shown in drawing 23, the reattachment is carried out to the front face of the abrasive tools 3 as cathode, and it contributes to the next processing. Furthermore, since the just charged particle can also be drawn near to the front face of the abrasive tools 3 as cathode, it is not buried on the surface of copper. The particle which remained on the front face of Wafer W and has been charged in negative on the other hand is also removable from the front face of Wafer W with above-mentioned Flushing. Moreover, when the polish abrasive grain PT uses the slurry SL charged in negative, it can remove similarly. Although it is necessary to remove a metal ion and PAKURU, without being easy to oxidize and deteriorating a copper front face when wiring formation material is copper, with this operation gestalt, the polish abrasive grain PT is just electrified beforehand, and this problem is solved by Flushing. In addition, as a polish abrasive grain, although the aluminum oxide (alumina) was mentioned as an example, when a cerium oxide, a silica, a germanium dioxide, etc. are used, it is the same.

[0073] As mentioned above, according to the manufacture method of the semiconductor device concerning this operation gestalt, the passive state film 108 is formed in the metal membrane 107 which embeds the slot wiring for wiring and the contact hole which were formed in the insulator layer 102. The passive state film 108 formed in the heights of a metal membrane 107 is removed alternatively. Compared with the usual CMP, flattening of the initial irregularity can be far carried out to high efficiency by electrolytic polishing removing alternatively the metal membrane 107 exposed to the front face by using the remaining passive state film 108 as a mask, and removing intensively by concentration to current density. Moreover, since the metal membrane 107 to which flattening of the initial irregularity was carried out is removed by the electrolysis compound polish which electrolytic polishing and chemical machinery polish compounded, it can remove the excessive metal membrane 107 in high efficiency far compared with the usual CMP. For this reason, even if it sets up the processing pressure force of abrasive tools 3 low, while sufficient polish rate is obtained and being able to mitigate the damage to a metal membrane 107, generating of dishing or erosion can be suppressed.

[0074] Moreover, when according to the manufacture method of the semiconductor device concerning this operation gestalt the excessive metal membrane 107 is removed and the barrier film 105 is exposed in order to stop polish, to change Slurry SL into what has a high polish rate to the barrier film 105, to change polish conditions, such as output voltage of the electrolysis power supply 61, and to remove the excessive barrier film 105. The excessive barrier film 105 is certainly removable, and when an exaggerated polish is required, the yield of dishing or erosion can be stopped small.

[0075] Moreover, in order to grind a metal membrane in high efficiency by electrolysis compound polish according to the manufacture method of the semiconductor device concerning this operation gestalt, Since the processing pressure force of abrasive tools 3 can be made into the low voltage force, for example in order to reduce a dielectric constant from viewpoints, such as low-power-izing and improvement in the speed, when a mechanical strength uses a low organic system low dielectric constant film and a porosity low dielectric constant insulator layer comparatively as a layer insulation film 102, the damage to these insulator layers can be reduced.

[0076] The absolute value of the amount of polish processings of a metal membrane is controllable by time to pass the amount of addition of an electrolytic current, and the wafer W of abrasive tools 3 with the operation gestalt mentioned above. With the operation gestalt mentioned above, although the case of the wiring formation process by copper was explained, this invention can be applied to various metal wiring formation processes, such as a tungsten, aluminum, and silver, without being limited to this.

[0077] Moreover, although the operation gestalt mentioned above explained the case of the electrolysis compound polish which compounded the chemical machinery polish which used Slurry SL, and electrolytic polishing using the electrolytic solution EL, this invention is not limited to this. That is, this invention can also perform electrolysis compound polish by electrolytic polishing of the electrolytic solution EL, and mechanical polishing by polished surface 3a of abrasive tools 3, without using Slurry SL.

[0078] Moreover, although the polish process until it acts as the monitor of the current value which flows between abrasive tools 3 and the electrode boards 23 and the barrier film 105 is exposed based on this value was managed with the operation gestalt mentioned above, it is also possible to manage all polish processes by the current value which acted as the monitor. Although similarly it acted as the monitor of the electric resistance value between abrasive tools 3 and the electrode board 23 and being considered as the composition which manages only the removal process of the barrier film 105 with the operation gestalt mentioned above based on this value, it is also possible to manage all polish processes with the electric resistance value which acted as the monitor.

[0079] Modification 1 drawing 26 is the schematic diagram showing the example of a changed completely type of the polish equipment concerning this invention. the polish equipment 1 concerning the operation gestalt mentioned above -- the energization to a wafer W front face -- conductive abrasive tools and a scrub -- the energization board 23 equipped with the member 24 performed As shown in drawing 26, the wheel-like abrasive tools 401 are good also as composition which also gives conductivity to the wafer table 402 which carries out chucking of the wafer W and is made to rotate it while they give conductivity as well as the case of polish equipment 1. Electric supply to abrasive tools 401 is performed with the same composition as the operation gestalt mentioned above. In this case, the energization to the wafer table 402 can form a rotary joint 403 in the lower part of the wafer table 402, and an electrolytic current can be supplied by considering energization to the wafer table 402 which rotates by the rotary joint 403 as the always maintained composition.

[0080] Modification 2 drawing 27 is the schematic diagram showing other modifications of the polish equipment concerning this invention. Chucking of the wafer W is carried out and the wafer table 502 to rotate is held by the retainer ring 504 which formed Wafer W in the circumference of Wafer W. While giving conductivity, conductivity is also given to a retainer ring 504 and electric power is supplied to abrasive tools 501 with the same composition as the operation gestalt mentioned above at abrasive tools 501. Moreover, a retainer ring 504 is covered and energized to the part for the above-mentioned barrier layer formed in Wafer W. Furthermore, electric power is supplied to a retainer ring 504 through the rotary joint 503 prepared in the lower part of the wafer table 502. In addition, even if abrasive tools 501 contact Wafer W, interference with abrasive tools 501 and a retainer ring 504 can be prevented by enlarging the amount of inclinations of abrasive tools 3 so that the crevice more than the thickness of a retainer ring 504 can be maintained in the portion of an edge.

[0081] Modification 3 drawing 28 is the outline block diagram showing other operation gestalten of the polish equipment concerning this invention. The polish equipment shown in drawing 28 is polish equipment which adds the electrolytic-polishing function of this invention to the CMP equipment of a conventional type, is contacted, rotating the whole surface of the wafer W in which chucking was carried out to the polished surface of the abrasive tools by which the polish pad (abrasive cloth) 202 was stuck on the surface plate 201 by the wafer chuck 207, and carries out flattening of the front face of Wafer W. The anode plate electrode 204 and the cathode electrode 203 are arranged by turns at the radial at the polish pad 202. Moreover, the anode plate electrode 204 and the cathode electrode 203 are electrically insulated by the insulator 206, and the anode plate electrode 204 and the cathode electrode 203 are energized from a surface plate 201 side. The polish pad 202 is constituted by these anode plate electrode 204, the cathode electrode 203, and the insulator 206. Moreover, the wafer chuck 207 is formed from the insulating material. Furthermore, the feed zone 208 which supplies the electrolytic solution EL and Slurry SL is formed in the front face of the polish pad 202 at this polish equipment, and the electrolysis compound polish which compounded electrolytic polishing and chemical machinery polish is attained.

[0082] Here, drawing 29 is drawing for explaining electrolysis compound polish operation by the polish equipment of the above-mentioned composition. In addition, the copper film 210 shall be formed in a wafer W front face. During electrolysis compound polish, as shown in drawing 29, after the electrolytic solution EL and Slurry SL have intervened between the copper film 210 formed in the wafer W front face, and the polished surface of the polish pad 202, direct current voltage is impressed between the anode plate electrode 204 and the cathode electrode 203. Current i is transmitted to the inside of a copper film 210 through the electrolytic solution EL from the anode plate electrode 204, and it flows to the cathode electrode 203 through the electrolytic solution EL again. Near [in the circle G shown in drawing 29 at this time], while a copper film 210 is eluted by the electrolytic action, a copper film 210 is further removed by the mechanical removal operation by the polish pad 202 and Slurry SL.

[0083] By considering as such composition, the same effect as the polish equipment 1 concerning the operation gestalt mentioned above is done so. In addition, arrangement of the anode plate electrode prepared in a polish pad and a cathode electrode is good also as a polish pad 221 with which two or more linear anode plate electrodes 222 were arranged at equal intervals in all directions, the cathode electrode 223 has been arranged to each rectangle field surrounded by the anode plate electrode 222, and the anode plate electrode 222 and the cathode electrode 223 were electrically insulated with the insulator 224, as it is not necessarily limited to the composition of drawing 28, for example, is shown in drawing 30. Furthermore, it is good also as a polish pad 241 with which the annular anode plate electrode 242 from which a radius differs, respectively has been arranged on this heart, the cathode electrode 243 has been arranged to the annular region formed between each anode plate electrode 242, respectively, and the anode plate electrode 242 and the cathode electrode 243 were electrically insulated with the insulator 244, for example as shown in drawing 31.

[0084]

[Effect of the Invention] According to this invention, since a metal membrane is ground by compound operation with mechanical polishing and electrolytic polishing, compared with the case of flattening of the metal membrane by mechanical polishing, alternative removal and flattening of the heights of a metal membrane become possible very much at high efficiency. Moreover, according to this invention, since abrasive tools are energized as cathode, the polish abrasive grain in the particle just charged beforehand or an abrasive material can draw near to abrasive tools, can prevent remaining to a wafer front face, and can aim at improvement in the yield. Moreover, according to this invention, since it becomes high efficiency removable [a metal membrane], it can suppress that polish rate comparatively sufficient also by the low polishing pressure force is obtained, and a scratch, dishing, erosion, etc. occur in the ground metal membrane. Furthermore, in order to obtain polish rate comparatively sufficient also by the low polishing pressure force, to accumulate and to reduce a dielectric constant from viewpoints, such as low-power-izing of a semiconductor device, and improvement in the speed, when a mechanical strength uses a low organic system low dielectric constant film and a porosity low dielectric constant insulator layer comparatively as a layer insulation film according to this invention, it can apply easily. Moreover, according to this invention, since it is efficiently removed because an electrolytic action works, and elution stops from a part for the outcrop of an insulator layer, the portion of the barrier film which remains on a layer insulation film, or a metal can secure the stopping accuracy of polish automatically, and can suppress dishing and erosion. Moreover, according to this invention, a polish process can be managed by carrying out the monitoring of the electrolytic current, and it becomes possible to grasp the advance state of a polish process correctly. Moreover, according to this invention, by carrying out the monitoring of the electric resistance value between abrasive tools and polar-zone material, current cannot flow easily, or even when grinding simultaneously the film and metal membrane to which current does not flow, a polish process can be managed correctly.

[Translation done.]

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